ANNUAL ANTENNA ISSUE

ham radio magazine

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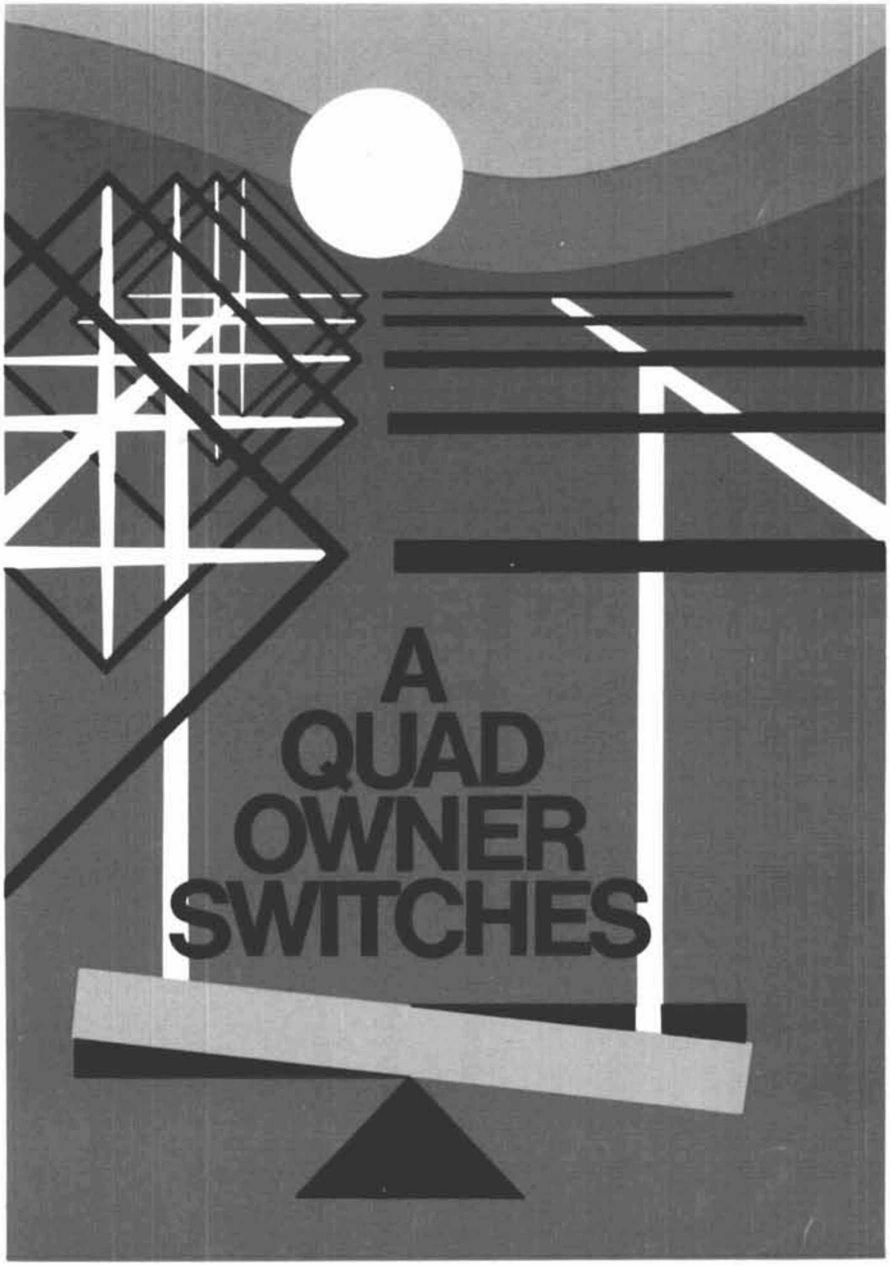
- improved cylindrical feedhorns
- the half-delta loop



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contents

Observation & Opinion

This month I present a guest editorial by one of our authors, Gary O'Neil, N3GO. Gary feels that operating procedures on 2-meter fm need to be changed and offers his suggestions. Alf Wilson, W6NIF, **editor**.

When the subject of Amateur Radio slips into a casual conversation, I spend a great deal of energy playing the role of recruiter. If successful enough at motivating an individual to join the family, I like to make his transition painless.

My latest recruit, although a licensed Amateur, had been inactive for some time. With a bit of persistence and a great deal of encouragement, I was able to pry him out of the closet and sell him on the virtues of 2-meter fm. After some shopping around, he was able to locate a nice compact 2-meter fm rig and carefully proceeded with the neat installation of his new acquisition into the family car.

Formerly an a-m operator on the high-frequency bands, but having some appreciation for channelized line-of-sight communications, he correctly deduced that a lengthy CQ would not be necessary. After listening to the limit of his patience, he decided to try "CQ, CQ CQ this is WA2— listening for any calls. What say somebody please?" He was answered immediately, welcomed to 2 meters, and quickly informed he was using incorrect procedure. On a few occasions that followed, he tried several variations of CQ with similar results until a neighborhood ham informed him, "You just don't call CQ on 2 meters!"

After a week or more of announcing he was listening on frequency to all of his available channels without response, he retreated back into the closet concluding that 2 meters is not used for talking. If current procedures were effective, I would be less likely to agree with him, but personal observations tend to support his comment. The "acceptable" procedure is not only ineffective, it is cold and uninviting.

The use of "listening on" or "monitoring" implies, "Call me if you have something important, otherwise I would rather not talk to anybody." Personally, I can justify only two reasons for calling a listener:

1. I know the person and I have something to discuss.

2. The person appears to have equipment trouble and should be made aware of it.

Another classic is, "QRZ the frequency?" If there truly is a stupid question, this one fits the category. Several hours of silence are broken by "QRZ . . . This is N2—!" This in turn is followed by — what else? Why, several hours of silence of course. Did that person really detect somebody calling him? The truth is, I am supposed to interpret the announcement as a CQ and give him a call — I think.

Clearly, if one announces he is listening, he is being self-contradictory; for at that moment, he is in fact talking and unable to receive. The obvious idea here is that the listeners wish to let other listeners know that they are not listening alone. Stated another way, they want everybody to hear them listening. On many occasions, I have heard stations respond by calling the listener after perhaps 30 seconds or so of inactivity. You guessed it — the listener got impatient and went off to listen somewhere else.

Collectively, these procedures tend to discourage and minimize 2-meter activity, which today is in competition with the TV cable industry. If we don't demonstrate our intentions to keep it active, we could very likely lose the 2-meter band. If it continues to appear we are going the way of CB, the FCC may decide to take early corrective action before the situation becomes uncontrollable. If the extreme sounds far-fetched (that is, the total loss of 2 meters), consider the "egg on the face" circumstances that CB has created for the FCC. How many times does one run out of gas before he starts watching the fuel gauge? The broadcast industry may or may not have a powerful lobbying organization, but why take the risk?

Aside from the legal ramifications, what is the problem with making Amateur Radio operating procedures at least spectrally universal? Why is calling CQ such a "no-no" on fm and shamefully sinful on a repeater especially? Why the concern with regard to the occasional use of a practical and informative operating procedure even though it differs from a habit created by a narrow view of the Amateur Radio disciplines?

Different modes, for convenience or efficiency, use formal operating procedures for very good reasons, such as high-volume traffic handling; but I fail to understand why a desire to communicate on 2 meters, in a manner similar to communications carried on in the high-frequency spectrum, needs to be initiated differently. Lengthy calls on 2 meters are in no way very useful and in the case of repeater operation, the procedure is even undesirable, but a short CQ can at the very least be tolerated.

Announce your desire to chat and assume listeners are present. CQ sounds like "seek you" and is perhaps key to its origin. More important, CQ invites conversation with newcomers and may just open a lot of doors. The use of abbreviations, Q-signals and slang creates the impression of a clique organization closed to outsiders. The image that 2 meters exhibits today discourages more than encourages, and I for one am bewildered by how it all began.

Lately, when I am coaxed into a ham radio demonstration, I hide my 2-meter rig, tune up on 40 and introduce my new recruits to some good-old-fashioned ham radio hospitality. When they are just about hooked, I take them out to the car, key up the local autopatch, and call their family to encourage their support. Then I immediately shut off the rig and send them home. If I ever happen to hear them calling CQ on the local machine, we will likely have a very nice chat. When we finally sign, they will never know that they goofed.

Gary O'Neil, N3GO

comments

one-wavelength versus full-wave

Dear HR:

Several correspondents have indicated an error in my January, 1982, article, "A Neglected Antenna for 40 and 80 Meters."

There can be a difference between a one-wavelength and a full-wave antenna. The one-wavelength reference pattern in my article was taken from Fig. 2-47 of the thirteenth edition *ARRL Antenna Book*. The text does not qualify this pattern as that of a harmonic antenna or a full-wave antenna, although it should.

If the one-wavelength wire were end fed, it would then theoretically match the reference pattern. End feeding would cause currents on each end of a one-wavelength wire to be out of phase; the antenna would qualify as a full-wave antenna and therefore nulls would appear broadside to the plane of the antenna. The center-fed, full-wavelength configuration will cause currents to flow in phase on both halves of the dipole. The result will be increased radiation from the sides of the antenna with the minimum lobe at the ends, and not as my reference pattern shows.

Using half-wave attachments to the open-wire feedline and selecting the proper impedance as I have shown in my article is still a good idea for maintaining a near omni-pattern.

I have written to the ARRL asking that the full-wave pattern (Fig. 2-47) be further qualified in the text and identified as that associated with a harmonic antenna. I understand that a new edition of the *Antenna Book* is in process.

Warren U. Amfahr, WØWL
Des Moines, Iowa

cheapie coax

Dear HR:

Gary O'Neil's article on traps in the October, 1981, issue of *ham radio*, page 10, was the answer to one of my antenna problems. I made a pair of 7-MHz traps to add to a 40-meter antenna for temporary or emergency use so it could be used on 40 or 80.

One of the other hams at work said he needed some traps for an antenna he wanted to build, so I took Gary's article to work for him to read at lunch. Several days later he said he'd made a pair of traps for 10 meters and they worked well.

Then he made a pair for 20, and crazy things started happening. One trap grid-dipped at 14 MHz and the other at 16 MHz. Investigation revealed that the 16-MHz trap was wound with a scrap of cheapie grade coax that had about 55 to 60 percent coverage by the outer conductor. The trap was rewound with a piece of good grade coax and it dipped at 14 MHz. Cheapie coax may be good for some things, but for traps, no cotton-pickin' way.

Wayne Stump, WB4AHZ
Lake Worth, Florida

good night!

Dear HR:

I'd like to respond to the comments of W6BQD in the January issue. The gentleman should recall the Biblical parable about attending to the beam in one's own eye before worrying about the dust mote in someone else's. For example, the best insult he could come up with for hams who like amusing phonetics is to liken them to folks from the "CB bands." The phrase is just as silly, grammatically, as 73s: it means Citizen Band bands.

While cute phonetics can easily be a problem for DX work, they shouldn't be for native speakers of English. Moreover, the clean ones are a lot easier to remember. For example, who could forget Under Forbidden Skies? Try it in standard phonetics. I don't know about low-band voice, but these memory aids are very common on 2 meters — and an awful lot of 2-meter ops, including myself, have never used a CB.

I think the FCC's objection to the use of Q signals on voice should also extend to the use of 73 — even though I use it myself, as well as a very common Q signal or two. The philosophy is the same: these were intended as abbreviations in CW work. There are some hams who don't know all of the Q signals, and (according to W6BQD) there are quite a few who don't know how to use the numbers right. Maybe we should all try *good night* for a change. It takes no more time to say, and it's a lot friendlier.

Phyllis M. Gilmore, KA6NFD
Colton, California

the other guy

Dear HR:

Your request to appeal to Chairman Fowler to "seek a relaxation of the projected cuts" is not, I hope, typical of all Amateurs.

We have requested reduction of government spending and government controls — but some people think it should be for the "other guys," and not where it affects "me."

As Amateurs, we should step in and offer our help to replace the services that the government will no longer provide. We probably can do it better and at less expense.

John Waterhouse, KA2GXS
East Aurora, New York

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Built-in 4:1 balun for balanced lines. 1000V capacitor spacing.

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Handles up to 200 watts output; efficient airwound inductor gives more watts out. 5x2x6".

Use any transceiver, solid-state or tube.

Operate all bands with one antenna.

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6 position antenna switch on front panel, 12 position air-wound inductor; coax connectors, binding posts, black and beige case 10x3x7".

MFJ-962 VERSA TUNER III

MFJ-962 $229.95 (+ $10)

Run up to 1.5 KW PEP, match any feed line from 1.8-30 MHz.

Built-in SWR/Wattmeter has 2000 and 200 watt ranges, forward and reflected.

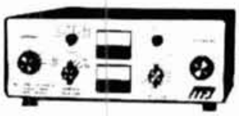
6 position antenna switch handles 2 coax lines (direct or through tuner), wire and balanced lines.

4:1 balun. 250 pf 6KV cap. 12 pos. inductor. Ceramic switches. Black cabinet, panel.

ANOTHER 1.5 KW MODEL: MFJ-961, $189.95 (+ $10), similar but less SWR/Wattmeter.

MFJ-10, 3 foot coax with connectors, $4.95.

MFJ-984 VERSA TUNER IV



MFJ-984 $329.95 (+ $10)

Up to 3 KW PEP and it matches any feedline, 1.8-30 MHz, coax, balanced or random.

10 amp RF ammeter assures max. power at min. SWR. SWR/Wattmeter, for./ref., 2000/200W.

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7 pos. ant. switch. 250 pf 6KV cap. 5x14x14".

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More Details? CHECK—OFF Page 100

presstop

CHICAGO AMATEURS HAVE WON AN ANTENNA RESTRICTION FIGHT. A new ordinance would have permitted the installation of radio communications towers and satellite receiving dishes only as part of a "planned unit development" and would have required a special use permit as well. There are no current height limitations in that city covering Amateur installations, but had local hams not acted quickly, the ordinance could have meant a sudden death to new Amateur growth there, as well as having been a bad precedent which other cities might have copied.

Chicago Hams Quickly Organized under attorney Jim O'Connell, W9WU. They deluged their aldermen with telephone calls and letters, and on February 25th, O'Connell appeared at a City Council meeting. Near the close of that hearing an amendment was introduced, by the bill's original sponsor, which would exempt antennas and towers erected by federally licensed Amateur Radio operators from the ordinance proposal. O'Connell felt that Amateur Radio would probably receive the needed exemption.

TRANSMITTERS CAUSING INTERFERENCE IN THE 440-MHz REGION have been T-Hunted down by Santa Barbara, California, Amateurs. These devices, which may be either locators for off-shore oil drilling or "sounders" for oil exploration, were noted to cause RFI as far as 60 miles away. At least one of these transmitters was found on a U.S. Coast and Geodetic Survey concrete benchmark along the Southern California coastline, completely unattended. Some Amateurs feel these devices may pose a public safety hazard in addition to disrupting UHF communications.

Another Site, 30 miles from the first, was discovered quite by accident. This time, however, a frequency near 1.6 MHz was being used. Both "boxes" bore labels written in French, and each appeared to transmit digital data signals in two distinct modes. Measurements made by Amateurs also indicated these units produce spurious radiation in the 980-MHz region when switching modes.

What Is Not Known is to whom these units belong and what purpose they serve. The FCC has reportedly been informed of their existence. At least one unverified rumor claims these are but two of several such devices that will eventually run the length of both coastlines.

A ONE TIME EXCEPTION IS BEING MADE BY THE FCC regarding the renewal of club and military recreation station licenses. If you held such a license and it expired between March 11, 1977, and July 14, 1980, you can file for renewal before June 1, 1982, and have the request granted. Not included are repeater WR prefix callsigns, even if one was your club's call. As far as the FCC is concerned, WR callsigns for repeaters is a dead issue.

THE COMMISSION HAS DENIED a Petition for Reconsideration on its recent relaxation of the Amateur identification rules (P.R. Docket 80-136). The petitioner wanted a change in the wording of the new I.D. rules but the FCC ordered the new rules to stand as implemented. Also denied were RM-3137, which would have raised the power limits on parts of the 2-meter and 3/4-meter bands up to 2 kilowatts dc (in order to encourage more EME communications); and RM-3181, a proposal to reduce legal power limits of hf radiotelegraphy from 1 kilowatt to 250 watts.

A NOTICE OF PROPOSED RULE MAKING AND A NOTICE OF INQUIRY concerning the expansion of radiotelephony on the hf bands has been issued by the Commission. P.R. Docket 82-83 specifically addresses radiotelephone expansion on 20 meters, while the NOI deals with methods to be used to implement such an expansion, along with the question of additional phone expansion throughout the hf spectrum. The FCC did note that there had been seven petitions in regard to the subject, and that while all were in general agreement concerning the 20-meter proposal, there was a wide divergence of views about other hf phone allocations. The comment cutoff date is July 1st, with reply comments due August 2nd.

REGION I OF THE IARU HAS ALREADY FILED IN OPPOSITION to the ARRL proposal for expansion of U.S. radiotelephone privileges below 14.2 MHz, stating that permitting U.S. Amateurs (who would be running high power and directional antennas) into that spectrum would adversely affect the operation of foreign hams who run low power and very basic equipment. They also noted the decline in sunspot activity which in turn is leading many Amateurs away from 15 and 10 meters and onto 20. Region I feels that an influx of high-power U.S. stations could make Amateur operations in other parts of the world impossible, thus causing some to move their phone operations into the CW segment of the band. The shared use of portions of 20 meters by some European government and fixed services was noted as well.

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More Details? CHECK—OFF Page 100

a quad owner switches

Which is the better antenna, quad or Yagi? Read this dialogue to find out why a well-known ham switched to Yagis after using a quad for years.

Thousands of words have been published about the relative merits of cubical quads and Yagi antennas, and probably millions of hours have been spent in on-the-air debates of the matter.

Quad proponents claim their square-shaped, three-dimensional antennas have more gain than Yagis do — perhaps as much as 2 dB more. To support their contention, they point to various studies of the two antenna types. But on the other hand, Yagi boosters claim there is little or no difference in the performance of the two antenna types — and they can point to research supporting their contentions.

This article will never settle such a long-standing controversy, but it does tell an interesting story about the experiences of one ham who became frustrated with his quad and switched to Yagis. Probably lots of people have become frustrated and replaced one kind of antenna with another, but this ham took the trouble to actually measure the gain of his old and new antennas under controlled conditions. What he learned should be of interest to others who want a big signal but are limited to a single tower on a city lot.

Our story is about Dave Bell, W6AQ, the motion picture producer who made "The Ham's Wide World," "Moving Up to Amateur Radio," and most recently "The World of Amateur Radio." An avid DXer, he installed a large multi-element quad on a 70-foot self-supporting tower at his Hollywood Hills home. The quad had a 27-foot boom, with three elements on 20 meters, four elements on 15, and five elements on 10. The quad design is a popular one that has appeared in the *ARRL Handbook* and *ARRL Antenna Book* for many years.

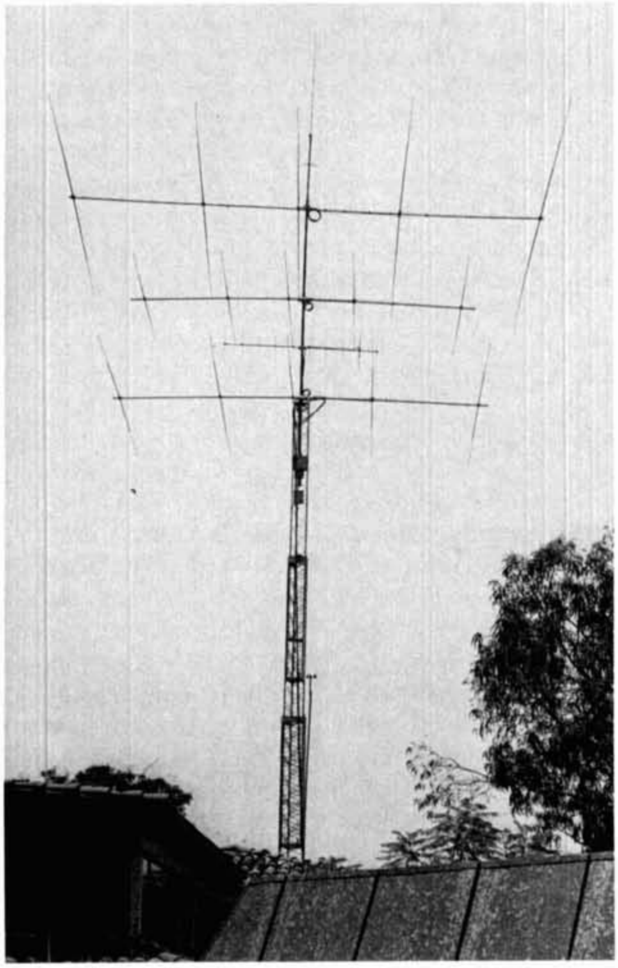
Based on the often-quoted finding that a quad delivers the gain of a Yagi 1.8 times its boom length,[1] Dave was hoping to come out even with nearby DXers using Yagis up to, say, 48 feet long. But years of slugging it out in the pileups convinced him the quad just wasn't delivering that kind of gain. Sometimes, in fact, the big quad came out second best to small trap tribanders in the Los Angeles area:

The painful decision to scrap the quad actually

By Wayne Overbeck, N6NB, and **Dave Bell, W6AQ,** c/o California State University, Fullerton, Department of Communications, Fullerton, California 92634

came when my friend Bernie, W6PJX, took me in a long-path pileup into Europe. He's using a TH3 (a three-element tribander) with a reflector that tilts as if a 60-pound owl crash-landed on it. That indignity, plus being regularly bested on 20 by TH6s (also tri-band Yagis), forced me to hear what my pals had been telling me. My razor sharp mind started counting alternatives to the quad — alternatives that would fit on a 50-foot-wide lot. Let's see, there's the Yagi and...

A major manufacturer (Hy-Gain) had just announced a new line of five-element monoband Yagis with relatively short booms — antennas that could be stacked on Dave's existing tower without creating an excessive windload or a neighborhood revolution. A "Christmas tree" stack of these close-spaced Yagis is about as big an array as most Amateurs on a city lot could swing, Dave felt. So he ordered the new Yagis.



The new stack of monoband Yagis at W6AQ; they work great, but don't look up at them from the patio below! (See text.)

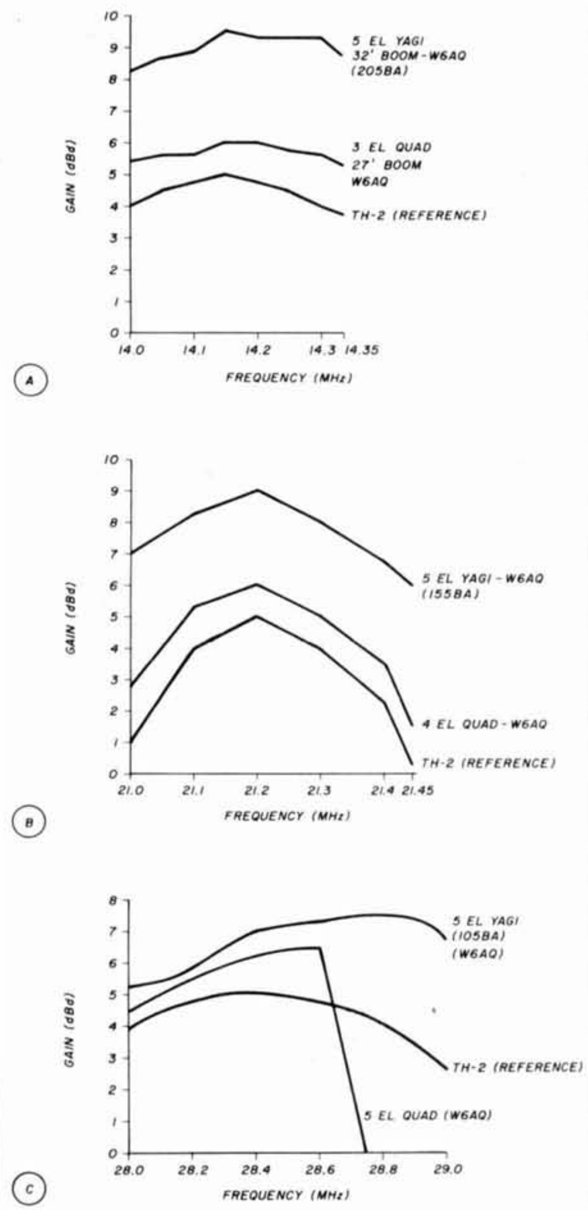


fig. 1. Test results for 20, 15, and 10 meters (A, B, and C respectively). Data confirms W6AQ's on-the-air experiences.

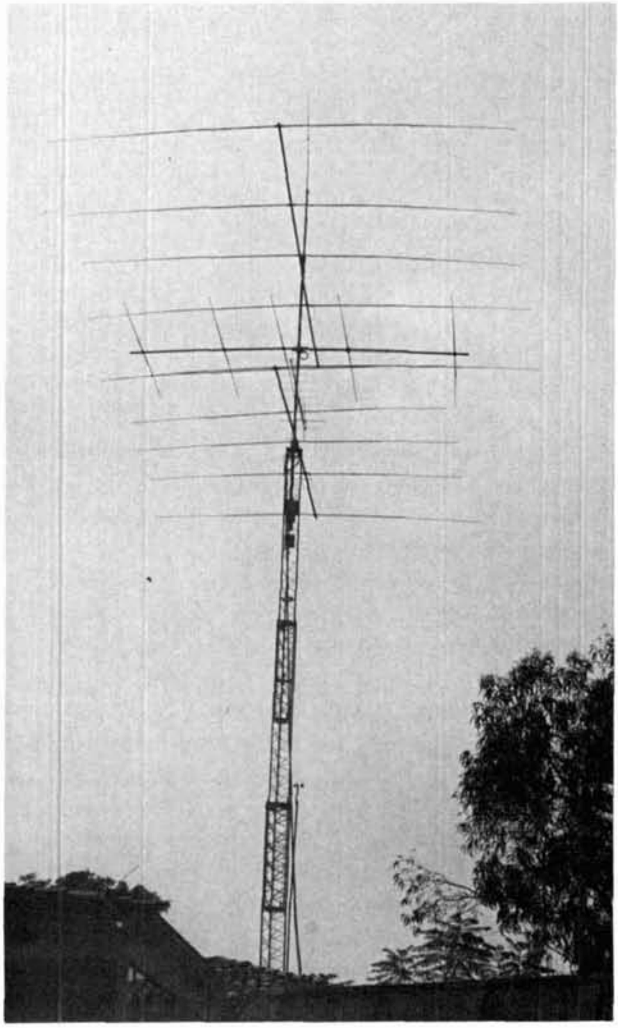
the gain measurements

Before Dave took down the big quad, we measured its forward gain on all three bands, using the techniques described in two previous articles.[2, 3] Briefly, the technique involved placing a reference antenna (a small two-element tribander) atop a trailer-mounted 70-foot tower beside Dave's antennas.

In these tests, a station about 20 miles away (but clearly line of sight from Dave's hilltop location) provided a steady signal for gain comparisons between the quad and the reference antenna at various points across the 10, 15, and 20 meter bands. The relative gain of the two antennas was measured and recorded, using a Drake R-4C receiver with the AGC turned off and an audio decibel meter reading the output.

The quad was then taken down and replaced with the three close-spaced Yagis. The 20-meter beam was placed on top, with the 10 in the middle and 15 on the bottom of the stack, using 7.5 foot vertical separation between antennas:

The 20-meter Yagi is on the top of my stack for two reasons: 1) It's the first one Hy-Gain got into production and consequently the first one I put up; 2) The twenty ought to be the farthest from the ground,



The final stacking arrangement, with the 10-meter Yagi at a right angle to the others. This configuration produced more gain on 10 meters than the in-line arrangement, but is it really 2-dB down in beauty?

I think, though I get kidded about it. I called Kit Kitterer at Hy-Gain to ask his opinion of the twenty on top and he said that was the obvious place for it but their ads showed it in typical Christmas tree fashion because that arrangement was more esthetically pleasing. (I know it's heresy, but I don't think antennas are measurable in terms of esthetics.) The 10-meter antenna was next to arrive, so it went on the tower next, and finally the 15-meter beam arrived and there you have it.

Even discounting any new antenna owner's anticipation of better results, I got and am getting far better on-the-air reports with the new Yagis.

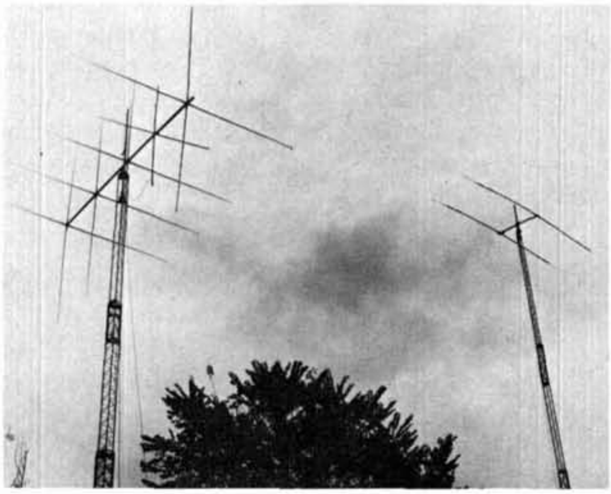
There is only one complaint I can voice about the Hy-Gain stackables, as they call them. It is somewhat unsanitary to sit beneath them inasmuch as the birds, who never cared for my quad, are absolutely in love with all of those straight branches I put up for them. When walking beneath my Christmas tree, the best advice is, don't look up.

To verify Dave's on-the-air observations about the relative superiority of the new Yagis, we repeated the gain measurements, using exactly the same hardware and test procedure as with the quad. The portable tower was positioned in the same place and the same reference antenna was used, with the same station providing the test signal again. The reference antenna was even stored indoors during the interval between tests to assure that its performance would not deteriorate. The only thing different during these second tests was that a stack of Yagis was now on Dave's tower where the big quad had been. Dave even measured the new coaxial cables against the old:

A friend of mine came upon a lot of new RG-213 at a bargain, so I of course bought some to use with the new Yagis. When I realized that it would present a variable in Wayne's measurements, I measured its loss. When the four-year-old RG-8 came off the quads, I measured its loss too. Predictably, the 213 and RG-8 were identical at 28 MHz. The old coax is feeding a pair of two-meter antennas and my low band wires now.

To standardize the height of each new antenna at the 70-foot boom height used in the prior tests, Dave's tower was lowered for the tests of the 20- and 10-meter Yagis, which were 15 and 7.5 feet, respectively, up the mast from the top of the tower. Thus each Yagi was measured at exactly the same height as the old quad.

The results of the test, shown in **fig. 1**, were no surprise to Dave because of his on-the-air experiences, but the extent to which the Yagis outperformed a quad of about the same size surprised everyone else.



Replica of W6AQ's quad set up for testing at N6NB. After careful pruning, its gain improved but still didn't match the gain of several Yagis that were tested on the same tower.

the results

At every single frequency where a reading was taken, the Yagis were superior to the quad, often dramatically so. On both 15 and 20 meters, the Yagis were typically 3 dB better than the quad. That makes as much difference as doubling the transmitter power output!

The 10-meter Yagi also outperformed the quad, but by a lesser margin, apparently due to interaction problems. The 10-meter Yagi's gain fell considerably below the manufacturer's specifications, while the measured gain of the 15- and 20-meter arrays was close to specifications (thus lending credibility to those specifications, especially since the original prototypes were undoubtedly measured in the clear; that is, unstacked). But we wondered if the 10-meter beam was performing as it should, even though it exhibited a good SWR and nearly 30 dB of front-to-back ratio.

To find out, we rotated the 10-meter beam 90 degrees on the mast, turning its boom to a right angle in relation to the 15- and 20-meter booms. Remeasuring the gain without changing anything else, we found that the 10-meter antenna's gain had increased almost exactly 1 dB all across the band. Obviously, there were — and probably still are — interaction problems on 10.

To show you that the demon antenna expert is really just a pussycat, after measuring 1 dB or so better gain when the 10-meter beam was swung 90 degrees, Wayne suggested we swing it back into line!

I couldn't believe it! "It'll gain at least 2 dB in beauty," he explained. "Humbug," said I, and the 10-meter beam remained pointed off in its own direction, louder and prouder.

Another surprising thing we discovered in the 10-meter tests was that the quad's gain abruptly fell off above 28.7 MHz. Up to that frequency, the quad's gain was close to that of the Yagi and it exhibited a seemingly normal front-to-back ratio (about 20 dB). But suddenly the quad's gain plunged downward; its gain was nearly 15 dB below the reference tribander at 29.0 MHz! However, rotating the quad revealed an incredible phenomenon: the quad had nearly 20-dB *back-to-front* ratio above 29.0 MHz. The reflector had ceased to function as such, and the first director had become a reflector!

My face is red, but I have my excuses in place. First of all, ten was basically deserted during the four-year period that I used the quad. Second, I rarely operate above 28.7. Third, my inherent laziness allows me to work stations "off the back" if signal levels are mutually acceptable.

Little did I know that in my case "off the back" could have been better than "off the front" since I never observed that curiosity. Had I done so I probably would have chalked it up as a long-path contact, though I doubt there are many long-path openings between L. A. and Detroit.

Frankly, I can't imagine the cause of the quad's not knowing which end was which unless mother nature took her toll on my solder joints and gremlin capacitances hexed the poor old wire monster.

repeating the experiment

Dave's quad was a faithful reproduction of a very popular design — one that has appeared in many editions of the ARRL publications. Several well-known DXers with years of antenna-building experience had helped build Dave's quad. Did they incorrectly measure the elements on all bands? Or had old age set in? Was there really something wrong with Dave's quad, or could this be viewed as an indictment of quads in general?

As we looked at the data, it was apparent Dave's quad wasn't performing as well as would be expected on any band — not just on 10 meters where it abruptly developed backward directivity halfway up the band. And it seems unlikely the elements were mismeasured on all three bands.

Then was the quad badly mistuned? Perhaps, but nowhere does the *ARRL Handbook* description of the antenna say the dimensions given may not work, and that each antenna must be individually tuned if it is to work correctly. If every cubical quad must be individually tuned after it is installed, whereas Yagis can be simply cut to published dimensions, that would be a real disadvantage of quad antennas.

To explore some of these questions, we built another cubical quad identical to Dave's, very carefully cutting the elements to the dimensions given in the *ARRL Handbook*. We put it atop the trailer-mounted 70-foot tower and placed the reference TH-2 beside it on another 70-foot tower. Since a variety of other antennas had already been measured in this test configuration, we could compare this new quad against a variety of different Yagis, both monobanders and tribanders.

When we put up the replica of Dave's quad, it was not resonant anywhere near the proper place in any band. In all instances, the elements turned out to be much too long in our installation, resulting in backward directivity much like that observed on 10 meters with Dave's quad. Using SWR plots made with the antenna at its full height as an indicator of resonance, we gradually shortened each driven element until it was resonant near the middle of the appropriate band.

Next, we calculated the *percentage* longer or shorter that the reflectors and directors were supposed to be with respect to the driven elements, using the *Handbook* dimensions. The result was an antenna that faithfully reproduced the *design concept* of the *Handbook* quad: the reflectors and directors were the same percentage longer and shorter than the driven elements as in the original design, although the actual dimensions of all the elements were much shorter than those given in the *Handbook*. In working with wire antennas, we have often found that the correct dimensions for a given frequency may vary somewhat from those published, depending on the size and type of wire, whether the wire is bare or covered, etc.

Once we had completed these adjustments, we got good results — but not as good as some cubical quad devotees would predict. Across the 20-meter band, the quad averaged about 1 dB less gain than a similar-size four-element Yagi that we had tested on the same 70-foot tower in the same place, using the same feedline and the same TH-2 as a reference (with the TH-2 also in the same place). On 15, the quad was consistently 2 dB down from a five-element Yagi we'd tested on the same tower. And on 10, the quad was about 0.5 dB down from a five-element Yagi — until we reached the frequency where the quad reversed its directivity. At that point, its gain dropped many, many dB below the Yagi's. In both on-the-air tests using skip signals and local measurements of directly radiated signals, we found the quad to be an excellent triband antenna, but no match for monoband Yagis of the same size.

Ah, you say, but this was a comparison of a triband quad against monoband Yagis and therefore unfair to the quad. To find out how well the quad would work as a monobander with elements for just one band, we tested it as a five-element 10-meter quad (that is, with the 15- and 20-meter elements removed). The extra elements made virtually no difference: if anything, the quad was a little better on 10 meters with the 15- and 20-meter elements than without them, altough the resonant frequency was a little lower with the extra elements. Even as a monobander, the quad still didn't match the gain of a similar size Yagi.

conclusion

What does all of this prove? Well, it suggests that Dave's quad wasn't working quite as well as it should have been. With patience and pruning, it could have been made to work a little better, but probably not as well as his new Yagi stack.

And that, really, was what Dave's experiment was all about: he wanted to know which antenna system is the best bet for someone who lives on a typical city-size lot as he does. Monster long-boom antennas (either quads or Yagis) were out of the question, but a stack of Yagis with relatively short booms was feasible — as was a multi-element quad. And Dave found out the stack of Yagis was the better performer.

Shortly after we finished testing the second version of the *Handbook* quad, Jim Lawson's article based on computer analyses of quads and Yagis appeared in *ham radio*.[4] Lawson concluded that an ideal long-boom quad might deliver up to half a dB more gain than a similar size Yagi, but that in the real world, optimizing a cubical quad may be so difficult as to make this theoretical gain advantage illusory. (Lawson also pointed out that tuning any big antenna near the ground is a sure way to guarantee that it will *not* be correctly tuned at its working height. If you want to optimize a quad, be prepared to repeatedly raise and lower it — or borrow someone's "cherry picker.")

Our field tests of quads and Yagis have produced much the same conclusion as Lawson's theoretical analyses. In years of measuring the gain of quads and Yagis, we have yet to find any long-boom quad in the real world that performs as well as an equal size Yagi.

We don't claim any of this settles the quads-versus-Yagis controversy for all time, but neither do we suggest that you try to hold your breath until Dave Bell switches back to a cubical quad!

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1. Lindsay, "Quads and Yagis," *QST*, May, 1968, page 11.
2. Wayne Overbeck, N6NB, "Measuring Antenna Gain with Amateur Methods," *QST*, October, 1977, page 11.
3. Wayne Overbeck, N6NB, "Quads and Yagis Revisited, *ham radio*, May, 1979, page 11.
4. James L. Lawson, W2PV, "Yagi Antenna Design: Quads and Quagis," *ham radio*, September, 1980, page 37.

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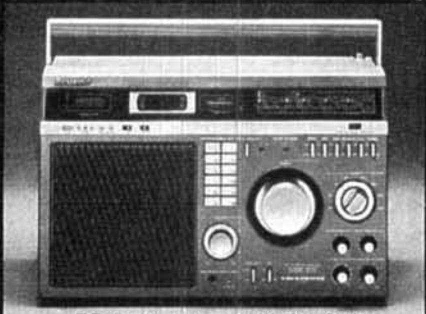
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dipole antenna over sloping ground

Even slightly uneven ground beneath your antenna can have a big effect on the pattern

Charts in numerous publications show the elevation patterns of a horizontal dipole at various heights above ground. These patterns assume perfectly conducting *flat* ground. For horizontally polarized waves, the perfectly conducting ground is normally a good assumption. But for those who don't live over *flat* terrain, is the effect of uneven or sloping earth significant?

A friend who lives on a hill informed me that, of his three antennas at 35, 50, and 100 feet (10.6, 15, and 30.5 meters) the lower-height antenna gave consistently better results on 10-meter DX. I therefore decided to investigate the effects of sloping ground under an antenna. The results are quite interesting.

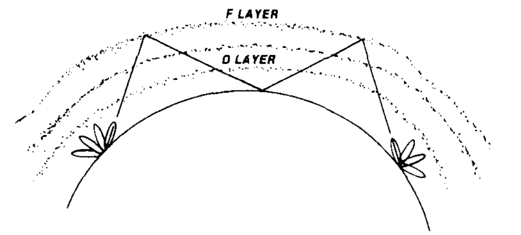

fig. 1. Dipole located at a height above ground which results in an elevation pattern that matches the arrival wave angle.

optimum wave angle

The ideal antenna system will be optimized in performance by placing the antenna at a height above the ground that will match the vertical elevation angle to that of the propagation wave, as in **fig. 1**. It has been found that the vertical wave angle for a New Jersey-to-London path is inversely proportional to frequency[1] (see **table 1**). Note that the mean vertical wave angle is 22 degrees on 40 meters, 11 degrees on 20 meters, 7 degrees on 15 meters, and 5 degrees on 10 meters.

A possible cause for higher vertical wave angles being useful at lower frequencies is D-layer absorption. This absorption, which is more significant at lower frequencies, increases at lower vertical wave angles because the signal travels further within the D layer. Since D-layer absorption is a function of ionization level, the wave on low frequencies may favor higher angles in the daytime. Also, for a given ionization-layer height, shorter-range communications involve higher vertical wave angles. Lawson[2] discusses useful wave angles. Good data on optimum vertical wave angles for DX Amateur communications for varying diurnal, seasonal, and solar cycles and frequencies is sorely needed.

dipole over flat ground

To find the vertical wave angle of a horizontal dipole over flat ground, see **fig. 2**. The dipole at height, h, above the ground has an image antenna an equal distance below ground. The reflected wave may be considered as emanating from this image antenna. The reflection from ground of a horizontally polarized wave also introduces an additional 180-degree phase shift. The incoming direct and reflected waves arrive at points A and B in the same phase, since they are both on the advancing plane-wave front. The reflected wave must advance the addi-

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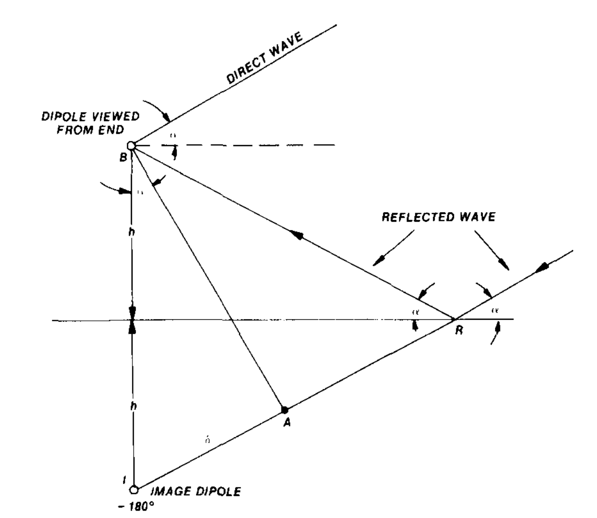

fig. 2. Dipole at height, *h*, above ground has an image antenna an equal distance below ground. The reflected wave may be considered as emanating from the image dipole starting with a phase shift of 180 degrees.

tional distance from A to the image antenna and therefore suffers additional phase shift plus the 180-degree reflection. Therefore, the two waves *don't arrive in phase*.

There are certain elevation angles, α, for a given antenna height that will result in the extra path length, δ, being 180 degrees. This 180 degrees will add to the reflected 180-degree phase shift and result in the two waves adding in phase, which will cause a maximum in the elevation pattern. Additional maxima will occur when $\delta = 540$ *degrees*, *900 degrees*, *1260 degrees*, and so on. (For a mathematical derivation of this effect, refer to Appendix 1.) The total phase shift, Δ, is equal to $\delta + 180$ *degrees:*

$$\Delta = 2h \sin(\alpha) + 180^\circ \qquad \textbf{(1)}$$

This equation can be solved for h in terms of Δ and α:

$$h = \frac{\Delta - 180^\circ}{2 \sin(\alpha)} \qquad \textbf{(2)}$$

By setting $\Delta = 360$ *degrees* (first maximum of the pattern) and α equal to the optimum vertical wave angle for each frequency band, the optimum antenna height for each band can be determined.

When α from the measured data of the London-to-New Jersey path is used, an interesting result occurs. The heights for 40 through 10 meters are 240, 472, 738, and 1033 electrical degrees respectively. The electrical height, h, of the antenna may be converted to the physical height in feet, h_f, by the relationship

$$h_f = \left(\frac{h}{360}\right)\left(\frac{984}{f}\right) \qquad \textbf{(3)}$$

where f is the frequency in megahertz. This results in optimum antenna heights of 94, 92, 96, and 101 feet (28.7, 28, 29, and 30.8 meters) for 40 through 10 meters respectively. The inherent uncertainties of the variables and the pattern width involved don't warrant specifying the height to the nearest foot, but the interesting fact is that heights of 90 to 100 feet match quite well useful wave angles for 40 through 10 meters.

dipole over tilted ground

A dipole over sloping ground is shown in **fig. 3**. The dipole is at a height, h, above the ground immediately below the antenna, at the base of a vertical supporting structure. The true electrical height, h_e, is slightly less and is the distance from the antenna at B to the ground along a line perpendicular to the ground.

The image antenna also lies on the perpendicular line at a distance h_e below ground. The first effect of tilted ground, therefore, is to lower the effective height of the antenna. This effect is rather small, however.

A large ground tilt of 11 degrees reduces the effective height of an antenna 100 feet (30.5 meters) high by only 1.8 feet (0.5 meter). A much more significant factor is the effect on the reflection angle at R of the ground tilt. For a mathematical derivation of the additional phase shift, Δ, refer to Appendix 2. The formula for phase shift is shown in **eq. 4**.

table 1. Arrival wave angle from England to the New Jersey coast (from reference 1).

frequency (MHz)	angle below which signals arrived 99% of the time (degrees)	angle above which signals arrived 50% of the time (degrees)	angle above which signals arrived 99% of the time (degrees)
7	35	22	10
14	17	11	6
21	12	7	4
28	9	5	3

$$\Delta = 2h \cos(\gamma) \sin(\alpha - \gamma) + 180^\circ \qquad \textbf{(4)}$$

Solving this equation for h in terms of Δ, α, and γ, we have

$$h = \frac{\Delta - 180^\circ}{2 \cos(\gamma) \sin(\alpha - \gamma)} \qquad \textbf{(5)}$$

Now consider what happens when even a small ground slope of +3 degrees exists. Using again the same wave angles of **table 1**, $\Delta = 360$ *degrees* for the first maximum; and solving for the optimum height, h, we have 108, 126, 168, and 252 feet (33, 38, 51, and 77 meters) for 40 through 10 meters. As can be seen, the effect of tilted ground is very significant. The effect on the lower frequencies is less pronounced because of the higher wave angles. The higher-frequency bands require that the antenna be much higher than when over flat terrain. The effect of a downward slope of 5 degrees, or $\gamma = -5$ *degrees* is also significant.

Optimum antenna heights are 78, 64, 56, and 51 feet (24, 20, 17, and 16 meters) for 40 through 10 meters. It seems that the combination of a location on a hill plus a high antenna can be detrimental: too much of a good thing.

patterns

Determining the elevation pattern of the dipole over ground from the phase shift of the reflected wave is straightforward. The direct wave is defined as 1 volt at 0 degrees, or $1\underline{/0}$ in polar form. The reflected wave is 1 volt at Δ degrees, or $1\underline{/\Delta}$ in polar form. The total voltage resulting from both waves is then $1\underline{/0} + 1\underline{/\Delta}$. Converting each of these to rectangular form and adding, we have:

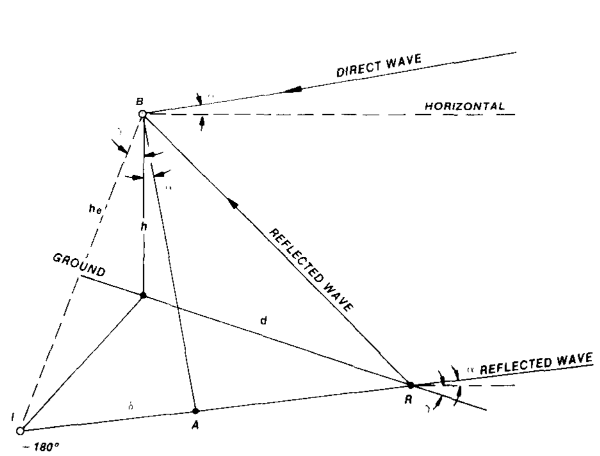

fig. 3. Dipole at height h above sloping ground. The slope of the ground, γ, is negative for ground below the horizon in the direction of propagation. The elevation wave angle, α, is still referenced to the horizon. The height is the length of a vertical supporting tower.

$$\begin{array}{rr} 1 & +j0 \\ \cos\Delta & +j\sin\Delta \\ \hline 1+\cos\Delta & +j\sin\Delta \end{array} \qquad \textbf{(6)}$$

and then converting back to polar form,

$$E = \sqrt{(1+\cos\Delta)^2 + \sin^2\Delta}\ \underline{/\tan^{-1}\left(\frac{\sin\Delta}{1+\cos\Delta}\right)} \qquad \textbf{(7)}$$

The absolute magnitude of the total voltage

$$|E| = \sqrt{(1+\cos\Delta)^2 + \sin^2\Delta} \qquad \textbf{(8)}$$

may be rewritten

$$|E| = (\sqrt{2})(\sqrt{1+\cos\Delta}) \qquad \textbf{(9)}$$

The E-field (horizontal) pattern that results varies from a maximum of 2 to a minimum of zero as the direct and reflected waves add and cancel in phase.

To calculate the actual gain of a dipole over ground, the effects of the mutual impedance of the dipole and its image must be taken into account.[3] For antennas high above ground, this effect is small. The relative E-field patterns found by the previous procedure are not affected by the mutual impedances.

The elevation patterns of a dipole antenna at 95 feet (29 meters) over flat ground are given in **table 2.*** The first maximum of each is shown in **fig. 4.** Notice how well the patterns match the optimum

*In the following text, **tables 2, 3,** and **4** refer to computer printouts. Copies of these tables may be obtained by sending a self-addressed, stamped business size envelope to *ham radio*, Greenville, New Hampshire 03048.

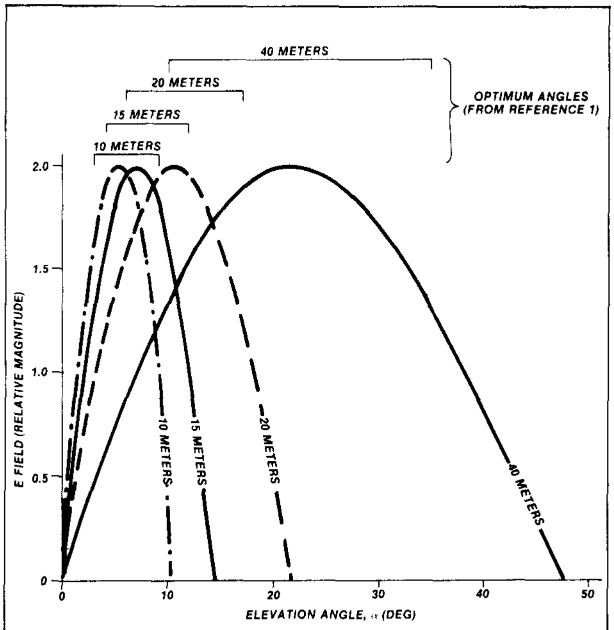

fig. 4. First maxima of the elevation pattern of a dipole 95 feet (29 meters) above flat ground for 40 through 10 meters. Notice how well the maxima match the optimum wave angles as shown in table 1.

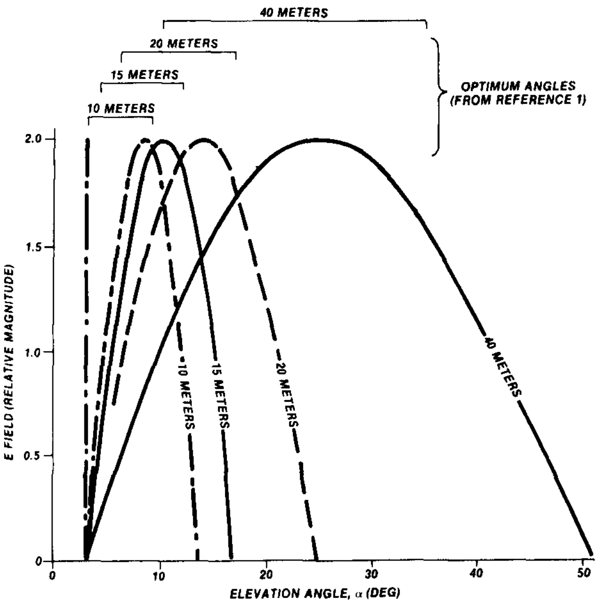

fig. 5. First maxima of the elevation pattern of a dipole 95 feet (29 meters) above ground with an upward slope of 3 degrees for 40 through 10 meters. Notice the misalignment of the maxima and the optimum wave angles, particularly at higher frequencies.

wave angle[1] on each band. The elevation patterns of a dipole 95 feet (29 meters) above ground for 40 through 10 meters (*ground sloping upward 3 degrees* toward the incoming wave) are given in **table 3** and **fig. 5** and in **table 4** and **fig. 6** over ground sloping downward −5 degrees. Notice the severe misalignment of the wave angle and the elevation pattern for both cases.

reflection point

The distance, d, from the base of the dipole's tower to the reflection point is

$$d = h \left[\frac{\cos \gamma}{\tan (\alpha - \gamma)} - \sin \gamma \right] \tag{10}$$

This is closely approximated by the simpler relationship

$$d \simeq \frac{h}{\tan (\alpha - \gamma)} \tag{11}$$

where d and h are in the same units. For $h = 96\ feet$ (29 meters), α = the optimum angle for each band over level ground ($\gamma = 0$). For Amateur bands 40 through 10 meters, d equals 235, 489, 773, and 1086 feet (72, 149, 235.8, and 325.8 meters). The effect of ground tilt on the distance to the reflection point is most significant on the higher frequencies. For $\gamma = -5\ degrees$, the reflection point moves in to 539 feet (164 meters) on 10 meters and 186 feet (56.7 meters) on 40 meters. In estimating the effects of sloping ground at your location, it's usually necessary to take into account the location of the reflection point. If, for example, your antenna is on a hill or in a valley of an extent less than the reflection-point distances involved, with flat ground beyond, then the net effect of the hill or valley will be to raise or lower the effective height of your antenna.*

Yagi antenna over tilted ground

An excellent treatment of Yagis over flat ground is given by Lawson.[2] He also discusses the tilted Yagi over flat ground. The case of a horizontal Yagi (perpendicular to a vertical tower) *over sloping ground* is similar to a dipole over sloping ground. The largest effect of a Yagi in this case is that the magnitude of the pattern lobes is reduced at higher elevation angles. A high-gain Yagi will also lower, very slightly, the angle of the maxima.

Tilted ground under a Yagi will also fill in the nulls

*A program for RPN calculators is available that gives the E-field in increments of 2 degrees for the elevation pattern of a dipole over flat or tilted terrain. Send a self-addressed, stamped business size envelope to *ham radio*, Greenville, New Hampshire 03048, for a copy.

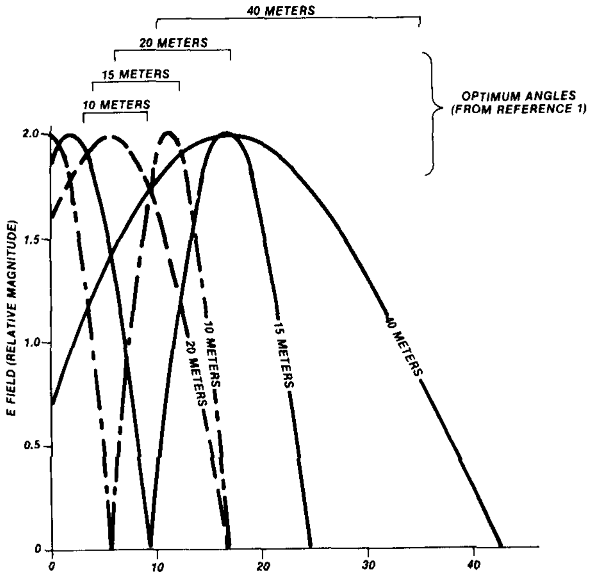

fig. 6. Low-angle maxima of the elevation pattern of a dipole 95 feet (29 meters) above ground with a downward slope of −5 degrees for 40 through 10 meters. Notice on 10 meters the misalignment is so severe as to actually have a null in the pattern at the desired wave angles.

in the elevation pattern, much like a tilted Yagi over flat earth. To understand why this is so, refer to **fig. 3**. Note that the direct and reflected waves arrive at the antenna at point B at different angles. Therefore, the free-space elevation pattern of the Yagi will reduce somewhat the voltage of the reflected wave impressed upon the terminals of the Yagi as compared with that impressed by the direct wave. The two waves *do not* have equal amplitudes. Therefore, even when phase cancellation occurs, complete cancellation of the voltage *does not* occur. This effect is most pronounced on high-gain Yagis with fairly large ground slopes.

acknowledgment

I'd like to thank John Hollis, Jr., WA4QLL, for writing the computer programs and preparing the tables of E-field elevation patterns. John and I have had many interesting conversations on antennas over sloping ground and we have run over-the-air tests investigating this effect.

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2. Jim Lawson, "Yagi Antenna Design: Ground or Earth Effects," *ham radio*, October, 1980, pages 29-37.
3. J.D. Kraus, *Antennas*, McGraw Hill, 1950, page 305.

appendix 1

Refer to **fig. 2**. Since A and B lie on the plane wave front of the incoming wave, BAI is a right triangle. Angle IBA is equal to the elevation angle. The hypotenuse of the right triangle is $2h$. Therefore,

$$\sin(\alpha) = \frac{\delta}{2h} \quad \textbf{(A1)}$$

and then

$$\delta = 2h \sin(\alpha) \quad \textbf{(A2)}$$

The total phase shift must include the reflection 180 degrees, so

$$\Delta = 2h \sin(\alpha) + 180° \quad \textbf{(A3)}$$

appendix 2

Refer to **fig. 3**. Again BAI is a right triangle. Angle IBA is equal to α plus γ. Since γ was chosen as negative for the downtilt configuration of **fig. 3**,

$$\text{angle } IBA = \alpha - \gamma \quad \textbf{(B1)}$$

The effective height of the antenna, h_e, is

$$h_e = h \cos(\gamma) \quad \textbf{(B2)}$$

therefore,

$$\delta = 2h \cos(\gamma) \sin(\alpha - \gamma) \quad \textbf{(B3)}$$

The total phase shift is

$$\Delta = 2h \cos(\gamma) \sin(\alpha - \gamma) + 180° \quad \textbf{(B4)}$$

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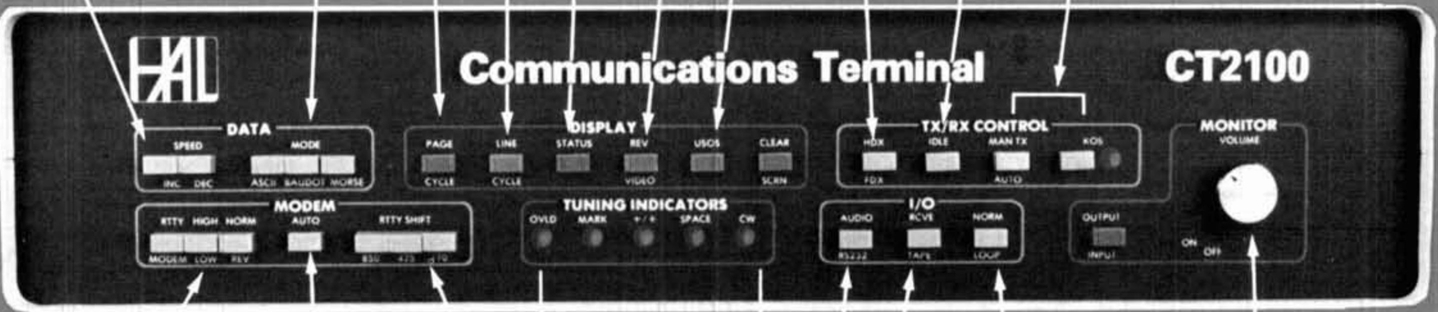

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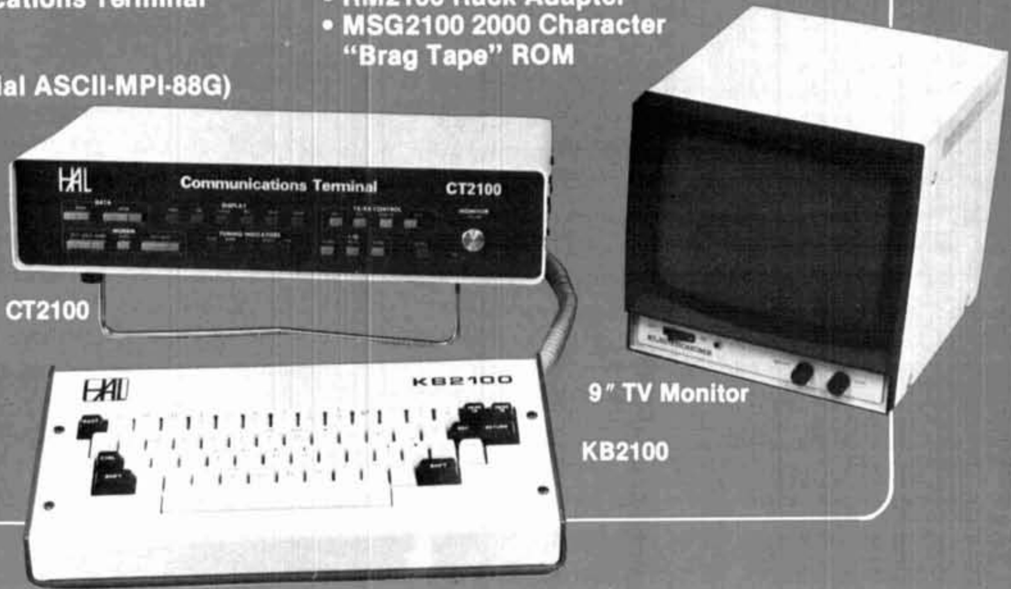

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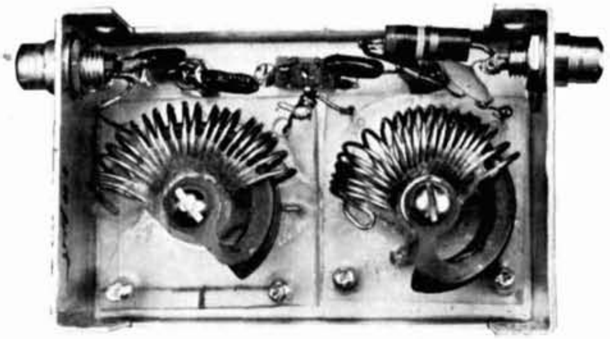

inductance-tuned lowpass antenna matching unit

An experimental design for low-power transmitters

This article is meant to raise more questions than it answers, because it is about a subject where many questions still need to be answered.

It's interesting to review the history of antenna matching in the design of manufactured final amplifiers. I remember working an old Johnson Viking Invader into loads with SWRs as great as 5:1. Later vacuum-tube equipment was good for loads with SWRs up to only 2:1. But note what all the manufacturers are selling us now: solid-state finals with no panel controls. Great — but suppose the load doesn't look exactly like 50-ohms resistive? You're putting out less power, or the safety relay opens up altogether. So obviously you may need an outboard gadget for your compact rig: an antenna-matching network, which is available from numerous manufacturers, usually called a "transmatch."

fig. 1. High-pass transmatches.

These commercial transmatches are usually copies or modifications of the original circuit by W1ICP[1] as "The Ultimate Transmatch." Its circuit is shown in **fig. 1a**. Variable capacitors C1a and C1b are ganged. Amateurs soon discovered that C1b did not contribute to a match: the basic circuit of **fig. 1B** works just as well. Virtually all rf matching networks except transformers are also filters, however, which may be lowpass, bandpass, or highpass configurations. It's evident that the circuit of **fig. 1B** is a highpass T net-

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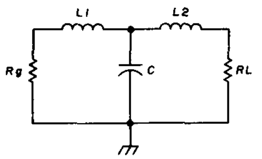

fig. 2. Lowpass T network.

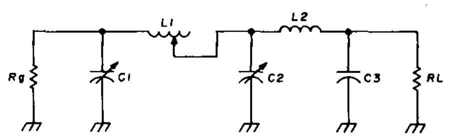

fig. 3. Capacitor-tuned pi-L network.

work. Such a circuit is just the opposite of what's needed to attenuate harmonics.[2]

With the prevalent highpass form of transmatch, one must rely for harmonic suppression entirely upon the lowpass untuned matching network built into the commercially manufactured transmitter's final amplifier, which is usually designed for a 50-ohm resistive load. Obviously, harmonics would be better suppressed if one could use a lowpass T as in **fig. 2.**

There is a practical problem of how to tune lowpass networks. In the original transmatch of **fig. 1,** most of the tuning is done by variable capacitors C1 and C2. When the mismatch is not very great, inductor L1 is varied only for band changing, taps and a rotary switch with grounded arm being used. Now in the case of the lowpass T, this design has been unpopular because of the difficulty of tuning inductors continuously over a wide range of values,[3] or even of step-switching them at a high-voltage point above ground, which makes construction more difficult. These facts apply even in the case of the old-fashioned conventional lowpass pi network. However, JA6GW[4] has succeed in building a lowpass T high-power antenna-matching network to handle SWRs of up to 3:1 on three bands. Referring to **fig. 2,** C is continuously tuned, L1 is untuned and L2 is step tuned.

lowpass experimental network

My objective was to design a lowpass tuned network for a QRP (low-power) portable transmitter that would match antennas under the variety of SWR conditions I was to meet, and, at the same time, would suppress unwanted frequencies sufficiently to *eliminate the need for the fixed-tuned 50-ohm transmitter output network altogether.* My first design was a capacitor-tuned pi, followed by a fixed-L network for additional harmonic suppression, as in **fig. 3.** To keep the equipment small I used for C1 and C2 small imported 365-pF variable capacitors with polystyrene dielectric. Such capacitors proved to be relatively unsatisfactory because of contact jitter, especially under salt-air conditions.[5]

The obvious direction to move lay in using something like a lowpass T and tuning L1 and L2 (**fig. 2**). I had previously simplified the half-toroid powdered-iron-vane tuned inductor made by K1KLO and described by W1CER in a low-power version of the original transmatch.[6,7] The photograph in the 1976 article shows that K1KLO apparently cemented one cut edge of his half-toroid core to a flat piece of metal, which was joined to the shaft collar. This was the core's sole support. As the shaft was turned for tuning, the core penetrated by varying amounts into the half-toroid coil.

The main advantage of K1KLO's design is that, with its thin support, the core can be turned almost 180 degrees. The disadvantage is that the support end of the core must be machined precisely at right angles to its plane. Thus the designer is pretty well limited to the use of powdered iron cores. This limitation is satisfactory for oscillator design, because temperature drift of permeability is so much worse in ferrite cores. However, for tuned-radio-frequency stages in receivers, the temperature change of permeability is usually of little importance, so that one can take advantage of the greater tuning range afforded by inserting ferrite cores into a coil. The same is true of tuned inductors in transmitter-matching networks, except for the important fact that a ferrite core saturates easily. Core problems are discussed further at the end of the article.

variable inductor

My simplified design of a variable inductance[3] entails the use of a flat sickle with central hub made from fiberglass-epoxy resin circuit board with the copper etched off. The half-toroid core is glued to the blade part of the sickle, and the hub is screwed to the end of the tuning shaft. With this technique the ends of the toroid do not have to be machined, thus making it possible to use ferrites.

Contrary to popular belief, an attempt to split an expensive ferrite toroid core need not end in disaster. A method that works well is to lay a straight-edge across the middle of the core, separating it into two equal parts. A pencil is used to mark the ferrite ring at the two places where the straight-edge crosses. Then use the edge of a small triangular file to saw along the pencil lines. Sawing from below the original line and at the sides of the ring helps. It's usually not necessary to saw very far before the core breaks.

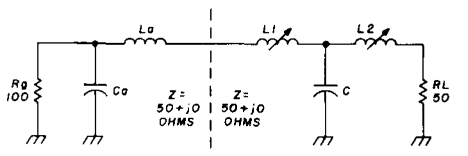

fig. 4. Inductance-tuned matching network.

The break may be slightly jagged, but not sufficiently so to make the core unusable. In stubborn cases, gripping each half of the core (protected by masking tape) in a small portable vise and striking a blow to one half, or to a chisel along the filed slot, should be considered. Yes, one toroid core does supply two tuning units.

The advantage of using ferrites can be appreciated by noting that one of my experimental units using Amidon FT 114-63 material at 10 MHz exhibited an inductance ratio of 5.9 to 1 between tuning extremes.

design considerations

The theory of matching networks is very much of. an electrical-engineering specialty. Fortunately, however, tables exist for values of circuit elements for matching a variety of sources to a fixed load of 50 ohms, there being a table for each of several choices of *Q* and each of four basic matching circuits, with equations given.[8,9,10]

In this design I've not attempted to provide an optimum result but rather to show that an improved design is feasible, leaving the full job as a challenge to the more capable Amateur. It's relatively easy to design a circuit with tuned-inductance series arms and fixed-parallel capacitors for a 50-ohm resistive match with a chosen *Q*. If the inductive arms have a large tuning ratio, one can design for the 50-ohm match values toward the middle of the tuning range and accept the range of load matching made possible by adjustment of the inductance values. For my portable operations this was not an unsatisfactory procedure, since I was using resonant, but sometimes loaded, monopoles and doublets. In the worst cases, the monopole ground plane might consist of only one wire laid along the railing of a motel balcony, or a doublet might be suspended very low above ground. I generally don't try to load up arbitrary lengths of wire. I especially avoid resonant wires with feed points close to a voltage maximum.

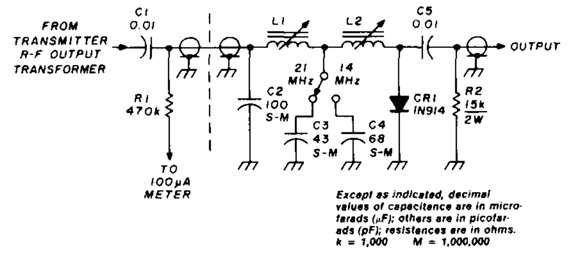

fig. 5. Circuit of experimental unit.

experimental circuit

The network I finally came up with was more of a mongrel than I had originally intended. It started out as the T network of **fig. 2** with a *Q* of 4 and switchable shunt capacitors for changing from 14 to 21 MHz, matching an assumed 100-ohm resistive output to a 50-ohm resistive load. I found the information shown in **table 1** by using reference 8 and making approximations. However, I wasn't able to use the original T network because, apparently, the inductance of rf chokes in the transmitter final amplifier caused a parasitic oscillation at about 4 MHz. This oscillation was eliminated by placing a 100-pF capacitor across the transmitter output.

table 1. Computed values for proposed T network of fig. 1; initial data used from reference 8 ($Q = 4, RG = 100\ ohms, RL = 50\ ohms$).

f (MHz)	X_{L1} (ohms)	L1 (μH)	X_{L2} (ohms)	L2 (μH)	X_C (ohms)	C (pF)
14	400	4.6	287	3.3	174	66
21	400	3.0	287	2.2	174	44

The new circuit could be split and described as a number of different combinations. After examining published tables in reference 10, I chose to look at it as an approximation of **fig. 4**, an L network of $Q = 2$, transforming 100 ohms to a 50-ohm resistive load — the load being a symmetrical lowpass T network of $Q = 6$ with 50 ohms resistive output and input. **Table 2** gives circuit parameters for 14 and 21 MHz.

Fig. 5 shows practical adaptation of **fig. 4**. The unit was connected to the output of a simple rf ferrite toroid transformer in the output circuit of a 2-3 watt transmitter for 14 and 21 MHz. For capacitor C2 I compromised on a single 100-pF silvered-mica unit. For tuning I used a 100-microampere meter in the transmitter to measure relative output. The 1N914 diode, CR1, provides a measure of peak rf output across itself. It charges C1 and C5. The discharge of C1 through R1 (470k) provides the current to give a relative reading on the meter. Resistor R2 is used as a means of draining atmospheric electrical charges off the antenna.

table 2. Computed values for circuit of fig. 4, approximated in final unit (data from reference 10). Rg is 100 ohms resistive; RL is 50 ohms resistive.

f (MHz)	X_{Ca} (ohms)	Ca (pF)	X_{La} (ohms)	L_a (μH)	X_{L1} (ohms)	L1 (μH)	X_{L2} (ohms)	L_2 (μH)	X_C (ohms)	C (pF)
	100		50		300		300		154	
14		110		0.58		3.4		3.4		74
21		70		0.39		2.3		2.3		49

tuning considerations

When one tunes for a maximum relative output voltage at CR1, this is essentially a measure of the voltage across the antenna cable and therefore a measure of the maximum output of the transmitter for a particular feed line and antenna, irrespective of SWR. One must assume, of course, that as a result of previous experience with the antenna, the SWRs are not unreasonable if amplitude readings and dial settings are similar to those that have been noted under controlled conditions with an SWR meter in the line. Self-oscillation of the final (not keyed in my transmitter) can usually be recognized as small key-up readings or readings without rf drive. VHF parasitics sometimes appear as very large meter readings. In one case when the antenna cable's shield was mostly torn from the plug, so that the final amplifier saw a load favorable for VHF oscillation, there was a very large apparent output reading at unusual tuning positions, but only during key down. An SWR meter showed very high readings.

construction

In the physical design of the unit, it was possible to build inductors with such a wide tuning range that no bandswitching of inductance was needed. In fact, L_a as seen from **table 2** was so much smaller than L1 that I simply regarded it as a part of L1, which I then wound identical to L2.

I designed the matching unit to fit into a Bud aluminum minibox (natural finish) CU3017A or equivalent, 3-1/4 by 2-1/8 by 1-1/8 inches (83 by 54 by 29 mm). **Fig. 6** shows the layout in the cover of the box. I mounted each inductor on an acrylic plate about 1-1/2 inches (38 mm) square. The central bushing is nylon 13/32 inch (10 mm) in diameter and 17/64 inch (6.7 mm) high, drilled for a standard 1/4 inch (6.4 mm) shaft of Formica. Using the techniques of reference 3, I cemented the bushings to the plates, which had oversized shaft holes.

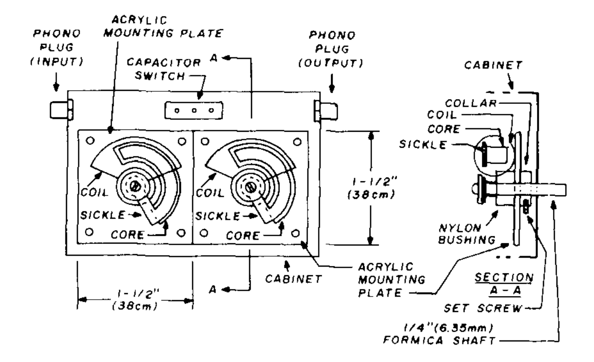

fig. 6. Matching network assembly.

For each half-toroid I wound twenty-two turns of No. 20 (0.8 mm) enameled wire on a 3/8 inch (9.5 mm) dowel, two more turns than would be used, because the coil would unspring slightly. A little more coil width would have allowed more core clearance in the finished product. I carefully wrapped this coil around the bushing, cementing twenty turns to the bushing and plate with Duro cement, having first brought leads out through holes in the plate. An rf-coil cement, Duco, or epoxy would all have done equally well. Holding the coil with a rubber band or small clamp until the cement hardens may be helpful.

For the cores, I split an Amidon 114-63 core as described above and in reference 3. It was necessary to use washers between the sickle hub and shaft end to space the core properly inside the coil with the shaft all the way into the nylon bearing. To hold each assembly in place I made shaft collars with set screws.

unwanted-output suppression characteristics

Fig. 7 shows the test setup for measuring unwanted-output levels relative to the level of the desired output. The low-power transmitter-matching circuit under test feeds a 50-ohm load of 8-watt dissipation, consisting of four 200-ohm, 2-watt resistors in parallel. This load is bridged by an arbitrary bleeder consisting of a 1000-ohm half-watt resistor in series with a 50-ohm half-watt resistor feeding a short piece of 50-ohm cable.* This cable can plug into one terminal of a precision variable rf attenuator; the one in this case was a unit once made by Hewlett Packard. I also used a high-frequency signal generator set arbitrarily at a high 50-ohm output level (mine was an old unit by Clemens Manufacturing Co.). Its output through 50-ohm cable can also plug alternatively into the attenuator terminal.

*For greater precision the capacitances across the resistors should be accounted for, as in the case of the attenuator in an oscilloscope rf probe.

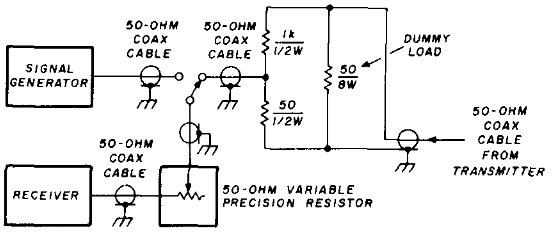

fig. 7. Layout for measuring relative strength of unwanted output components.

The other terminal of the attenuator goes to a stable communications receiver with a good AGC meter (S-meter). Mathematically it can be demonstrated that when the cables are matched at the sending end (not necessarily at the receiver) on any one receiver frequency setting, the output from the bleeder fed through the attenuator, and that from the signal generator fed through the attenuator, are the same — except for attenuator settings when the AGC meter reads the same. Negligible cable losses are assumed.

The procedure for measuring relative unwanted output is as follows:

1. The bleeder output from the transmitter dummy load is put through the calibrated attenuator and a setting, A, made to give a convenient AGC-meter reading with the receiver resonated to the transmitter fundamental frequency. Setting A is noted.

2. The signal generator is now plugged into the attenuator instead, with at least 20 dB of its own 50-ohm attenuator in use (to make sure of having a 50-ohm source). It is tuned to the receiver and a new attenuator setting, B, is made to bring the AGC-meter needle to the same point as before. The setting is recorded. The receiver now shows that the signal generator output and the bleeder output are equal.

3. With the transmitter running again, a harmonic or other unwanted frequency is tuned in.

4. Again the transmitter bleeder output through the attenuator is adjusted on the attenuator dial to a new convenient AGC-meter reading. The new attenuator setting, A', and the new meter reading are recorded.

5. Again a new signal-generator output (with its own attenuator unchanged from **step 2**) on the new frequency is put through the attenuator. The procedure of **step 2** is followed, and attenuator setting B' for the AGC-meter reading of **step 4** is recorded.

6. The number of dB that the signal generator was below the transmitter-bleeder output for the fundamental is $(A\text{-}B)$. The number of dB for the unwanted signal is $(A'\text{-}B')$, which may be negative, so the unwanted signal is $(A\text{-}B)\text{-}(A'\text{-}B')$ below the fundamental in decibels.

Table 3 shows the approximate results of the tests at 14 MHz.

some final observations

I've demonstrated that it's possible to build a simple tuned output network for a low-power rf final amplifier that has matched portable antennas in a variety of situations and is, at the same time, a lowpass filter with very satisfactory suppression of unwanted frequencies. However, as stated at the start, this achievement raises more questions that it answers.

In the first place the design, as mentioned above, was not optimized and I have not determined the exact range of loads that can be matched. Also, for the range of different possible settings, there must be a wide range of Qs, that I've not calculated. This is fair-to-poor ham practice, but terrible engineering. There's been a lot of theoretical research on matching networks and some practical engineering data published, but it appears that much more application information is needed.

The tables of matching-network parameters mentioned earlier are an example of good application information, but they are chiefly concerned with matching a fixed load, generally 50 ohms resistive. The mere question of how to express load-matching capabilities and limitations of a tunable multi-element circuit is a difficult one to answer. Standing-wave ratio is a convenient measure of a mismatch to be matched, yet anyone familiar with the Smith chart knows that any SWR circle intercepts a variety of circuit parameters and that it is these values that limit matching capabilities, not the SWRs.

Returning to **fig. 2**, for a given design one could superimpose parametric curves on a Smith chart — for instance, varying L1 with L2 and C being fixed. One could do this for different values of L2 and C. From these curves one could see limits of SWR and circuit parameters for a particular design. However, the real problem is to *optimize* a design, starting with expressed limits of loads to be matched. We have here a problem worthy at least of a Master's degree

table 3. Approximate attenuation of unwanted signals from low-power transmitter at 14 MHz fed through antenna-matching unit to 50-ohm resistive load. Transmitter final was push-pull 2N3948s.

f (MHz)	dB below wanted signal
28	55
42	70
7 (fromVFO)	48

for some technically oriented engineering-school ham with skill in computer programming.

Then there's circuit Q, which will vary as the circuit is tuned. Does present textbook material do enough to relate the defined Q of a filter-circuit element to its overall Q, and how does this relate to the simple $\omega L/R$ of an LRC tank circuit so well explained in the textbooks? Then, what about the low Qs (some say not above 4) so frequently specified? The limitation here cannot be the passband as it is with vacuum-tube power-output circuits. I must guess that the higher-Q transistor-output circuits might tend to oscillate at some unwanted frequency where the matching circuit no longer matches but presents the collector circuit of the final amplifier with a load that would be favorable for oscillation — but I've not seen this in print. Passband characteristics involving harmonic suppression have been treated in various places. They must be of concern in an optimum design.

Finally there is the question of the behavior of the core. Ferrites saturate at a low magnetomotive force, but with a half-toroid we have a big air gap. Nevertheless, we should design for a large enough cross-section area to stay far below saturation. In fact, core nonlinearity produces harmonics that did not exist in the transistor output. To know where we stand relative to saturation requires knowledge of the rf current and the core position for each set of load parameters. High currents cause excessive heat, which will do permanent damage to a core.

Perhaps we should raise that proposed Master's degree to a Doctorate. I'm sure JA6GW already qualifies,[4] but unfortunately he's shown us only part of his technique. It's quite likely, though, that experimentation alone will produce some useful, but not necessarily optimum, designs for higher-powered equipment than I've been using. Go to it, experimenters.

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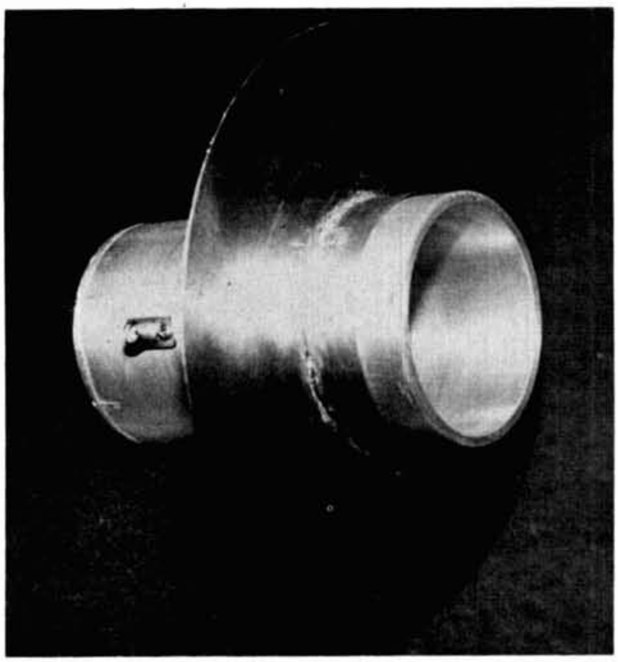

second-generation cylindrical feedhorns

Improved feedhorn provides superior parabolic antenna system performance

My original article describing cylindrical feedhorns[1] for use with parbolic reflectors appeared in *ham radio* in May, 1976. Judging from the number of inquiries that have been — and are still being — received, the subject is obviously pertinent to many Amateurs and experimenters interested in working in the UHF and SHF ranges. Variations of the design have been used on the 1296- and 2304-MHz Amateur bands as well as the MDS[2] and ITFS[3] bands. The design is also well suited for use in the 3300-3500 MHz Amateur band.

I recently experimented with cylindrical feedhorns for reception of satellite TV signals in the 3.7-4.2 GHz band. The design requirements here are similar, but in my case much more stringent — not because the frequency is higher, but because I chose to use a very small-diameter dish reflector (8-foot, or 2.4 meters). Those who are familiar with TVRO design requirements know that 10-foot (3-meter) or larger reflectors are almost always specified. Therefore, everything in my system had to be exactly right to produce acceptable satellite TV pictures using the 8-foot (2.4-meter) dish. This meant that I had to pay particular attention to details.

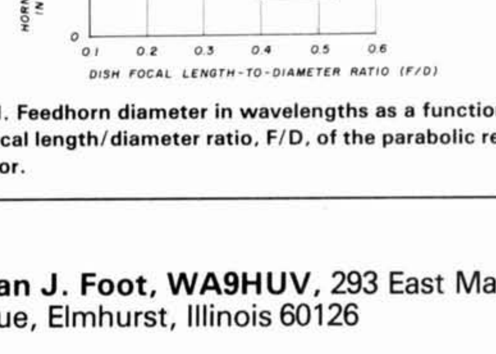

fig. 1. Feedhorn diameter in wavelengths as a function of focal length/diameter ratio, F/D, of the parabolic reflector.

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While this activity is not normally considered Amateur Radio in the usual sense, the modifications I had to make to the original design are certainly applicable to the UHF and microwave Amateur bands. The purpose of this article is to describe the changes and the associated improvements in performance that were achieved. This information should be helpful to Amateur experimenters and others working with parabolic reflectors who are interested in obtaining superior performance from their antenna systems.

a review of feedhorn parameters

Important feedhorn parameters are length, diameter, and probe location. The most important of these is the inside diameter of the horn, which is tailored to match the associated reflector. The probe location is calculated after the diameter is established.

The original article specifies a minimum diameter of about 5.68 inches (14.4 cm) for the 1215-1300 MHz application to operate above the cutoff frequency of the circular guide. A horn this small has a very broad beam and so would normally be used with a very deep dish. Large-diameter horns produce narrow patterns and higher gains. Generally the diameter is selected to match the F/D ratio of the associated parabolic reflector to achieve optimum design. A match is achieved when the gain of the horn off boresight at the periphery of the dish is approximately 10 to 15 dB below the gain on boresight. This point is illustrated in fig. 3 of the original article. Note that my 3.7-4.2 GHz horn has a diameter of 2.25 inches (5.7 cm), which provides a good match to my 0.387 F/D ratio 8-foot (2.4-meter) reflector.

Fig. 5 of the original article was difficult to read because the graph contained no grid. This important graph has therefore been reproduced here in **fig. 1**, but in a more universal form. Instead of specifying diameters for a specific frequency, diameter is specified in terms of wavelength, d/λ_0. This makes the graph useful at any frequency. For example, from **fig. 1** the diameter of a horn used with a dish having an F/D ratio of 0.387 is $0.75\lambda_0$. Therefore, the 1296-MHz feedhorn should have a diameter of 6.83 inches (17 cm):

$$d = 0.75\lambda_0$$
$$\lambda_0 = 9.113 \text{ inches } (23 \text{ cm})$$
$$\text{Therefore, } d = 0.75 \times 9.113 = 6.83 \text{ inches } (17 \text{ cm})$$

The relatively critical probe location can be determined once the horn diameter is established. The original article describes the probe as being located a quarter *guide* wavelength from the shorted end of the horn. The probe length is slightly shorter than a quarter *free-space* wavelength because of end capacitance. Reference should be made to the original article, which fully describes probe parameters and the tune-up procedure.

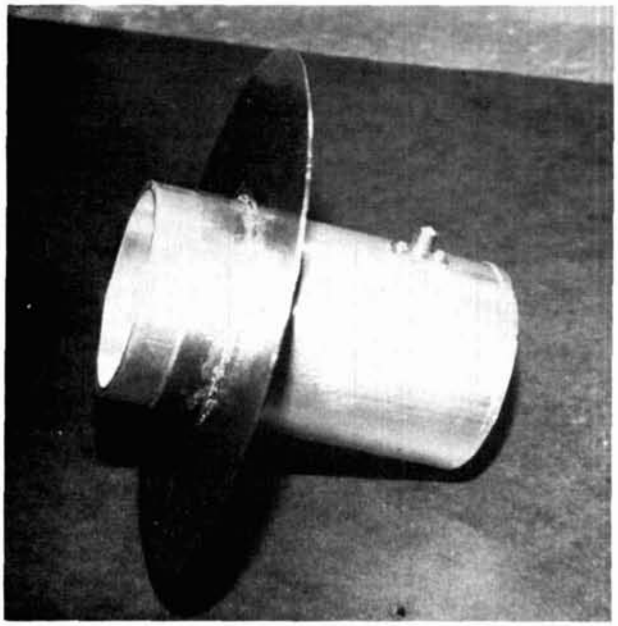
problem areas

Up to this point it has been assumed that the beam cross-section is circular and therefore that the reflector would be equally illuminated all around its circumference. Fortunately this is as very good assumption for cylindrical horns, especially those having large d/λ_0 ratios. In contrast, rectangular waveguide horns, which do not produce circular beams, require that a flare be added in the electric plane to achieve uniform illumination* in both the electric and magnetic planes.

Large-diameter cylindrical horns, such as might be used with shallow reflectors, generally exhibit side lobes as high as 8 to 10 dB below the peak of the main beam. This is not efficient and is particularly undesirable in TVRO systems.

Besides beam cross-section ellipticity and side lobes, there is a third effect relating to the abrupt discontinuity where the wave is launched from the open

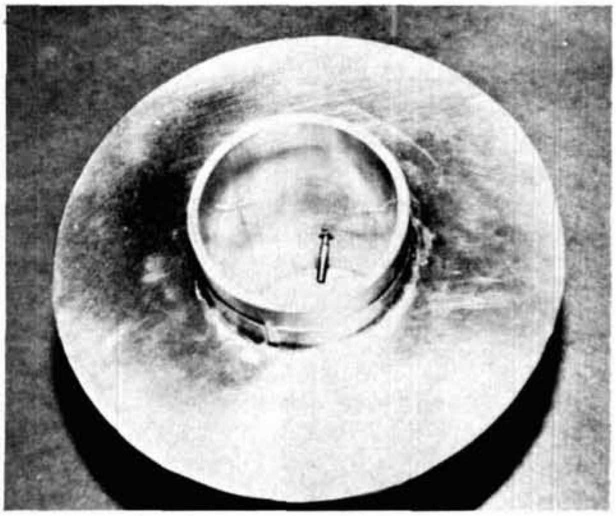
*The reference here to illumination of the dish denotes use as a transmitting system. Based on the reciprocity theorem, the system will work equally well for receiving purposes, but it is probably easier to visualize in the transmitting mode.



Second-generation feedhorn has space-age look. This 2¼-inch (15.7-cm) OD horn operates across the 3.7-4.2-GHz satellite TV band. Rf-choke disc increases gain by 2 dB and significantly improves overall system performance.

end of the horn. The discontinuity causes what is sometimes referred to as a back radiation.[4] The amount of back radiation is large for small-diameter horns but approaches zero for diameters larger than one wavelength. In the present application, horn diameters greater than a wavelength would be used with only very shallow (large F/D) dishes.

The cylindrical feedhorn is in reality a short section of circular waveguide with its open end coupled into space. Since the impedance of circular guides is always greater than the 377 ohms of free space,[5] a small amount of energy will be available for back



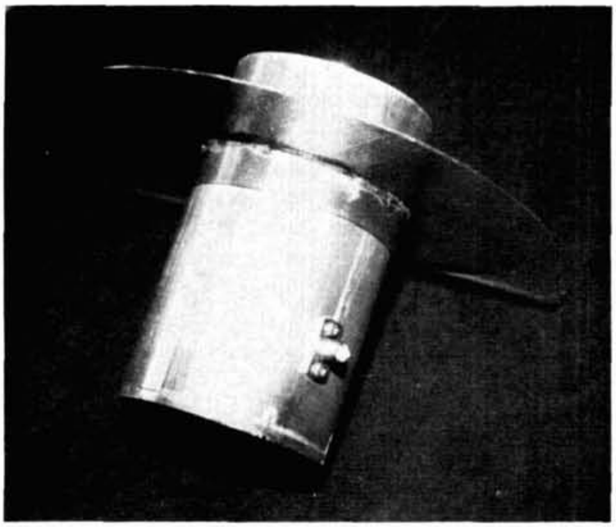
Another view of the horn showing probe location, which is calculated after horn diameter is established. The most critical horn parameter is inside diameter, which is designed to match the associated reflector.

radiation, while some energy may be reflected back into the coaxial input circuit. A means therefore is needed to reduce the discontinuity at the mouth of the horn; this should reduce VSWR and increase gain and efficiency.

matching the feed horn to free space

Experiments have shown that the addition of an rf choke on the outside of the feedhorn near the opening is very effective in reducing back radiation and providing a better impedance match. Measurements show that the resulting increase in gain of the main lobe is between 1 and 3 dB, depending on the ratio of d/λ_0. VSWR measurements show that best impedance match is obtained when the choke is located at the best gain position.

The choke is a flat washer positioned coaxially on the horn and located behind the open end. The choke used for the 4-GHz horn was 6 inches (15.25



The flat disc rf choke is very effective in reducing back radiation and providing a better impedance match. VSWR measurements show that the best impedance match occurs when the choke is located at the best gain position. Details for adjusting the choke are given in the text.

cm) in diameter and it was positioned approximately 1-1/4 inches (3.175 cm) behind the opening. Note that the distance from the open end of the horn along the metal surface to the periphery of the choke is approximately one wavelength. Since this distance is critical, provisions are made for adjusting the position of the choke for tuning purposes. The effectiveness of the choke becomes clearly evident as it is moved back and forth during gain tests. Also, pattern tests show that the choke is effective in reducing minor lobes to very low levels and circularizing the

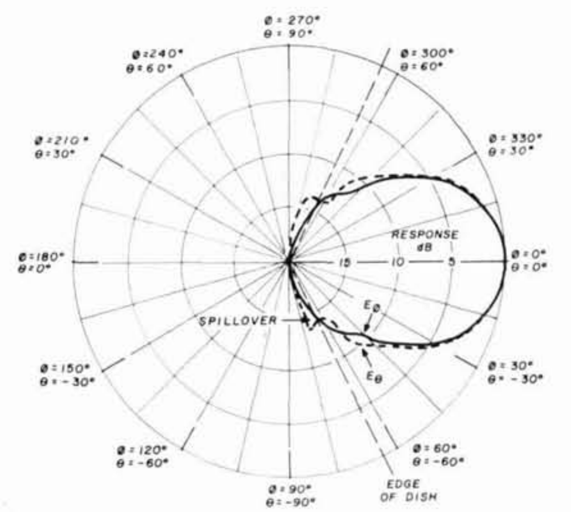


fig. 2. Patterns of the 4-GHz feedhorn after having been adjusted for maximum gain.

beam cross section. Thus, the choke is instrumental in improving *all* of the potential problem areas. **Fig. 2** shows the patterns of the 4-GHz horn in both the electric and magnetic planes after the choke had been adjusted for maximum gain.

Fig. 3 illustrates the mechanical details of the 3.7-4.2 GHz horn, including the choke. Note that all of these dimensions can be scaled to other frequencies in proportion to wavelength except for probe location. The latter is a function of guide diameter, which in turn depends on F/D ratio of the reflector. **Fig. 4** is a graph showing the probe location in terms of d/λ_0.

design example

The amount of Amateur activity on 1296 MHz has been increasing rapidly during the past few years. Seven-foot (2-meter) diameter dishes are quite popular on this band because commercial units intended for UHF TV are easily modified for use at 1296 by the addition of screening and a more suitable feedhorn. It is appropriate, therefore, to include with this article a 1296-MHz design example of an improved feedhorn for this application.

Most 7-foot (2-meter) reflectors have an F/D ratio of approximately 0.38. From fig. 5 of the original article, the horn diameter is 6.75 inches (17 cm). The length is 12-14 inches (30-36 cm), but this dimension is not critical. Free-space wavelength is calculated as follows:

$$\lambda_0 = c/f_0$$

$$\lambda_0 = \frac{3 \times 10^{10}}{1.296 \times 10^9 \times 2.54} = 9.11 \text{ inches } (23 \text{ cm})$$

where λ_0 = *free-space wavelength (inches)*

$c = 3 \times 10^{10}$ (cm/sec)

$f_0 = 1.296 \times 10^9$ (Hz)

Guide cutoff wavelength is calculated as follows:

$$\lambda_c = 3.42r$$

where λ_c = *cutoff wavelength*

r = *horn radius*

$$\lambda_c = 3.42\,\frac{6.8}{2} = 11.63 \text{ inches } (29.5 \text{ cm})$$

The cutoff frequency, f_c, is 1016 MHz.

Finally, guide wavelength, λ_g, is:

$$\lambda_g = \frac{9.11}{\sqrt{1 - \left[\frac{9.11}{11.97}\right]^2}}$$

$$= 14.057 \text{ inches } (35.7 \text{ cm})$$

In other words, the probe should be 3.5 inches (8.9 cm) from the shorted end of the horn. The probe is slightly shorter than $\lambda_0/4$, or about 2-17/64 inches (5.75 cm). Its length should be adjustable over a distance of about ± 1/4 inch (6mm). The adjustment for minimum VSWR should be made with the choke located at the maximum gain position. The technique illustrated in fig. 6 of the original article can be used for probe adjustment.

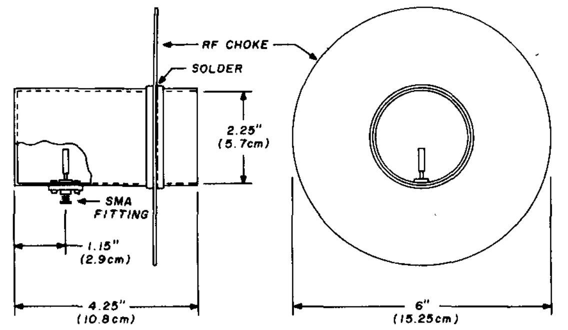


fig. 3. Mechanical details of improved 3.7-4.2 GHz feedhorn.

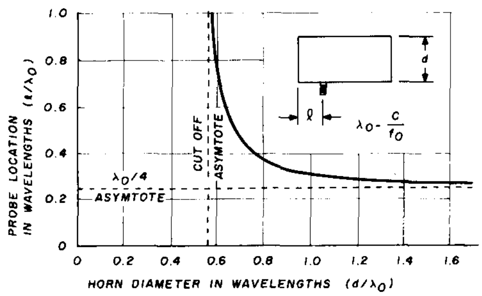


fig. 4. Probe location in terms of horn diameter in wavelengths.

The 1296-MHz feedhorn should be equipped with an 18.5-inch (47-cm) diameter, 0.032-inch (0.8-mm) thick brass rf choke, located approximately 2-1/2 inches (6.35 cm) behind the open end of the horn. The inside diameter of the choke should be greater than the outside diameter of the horn, so that a 1-inch-wide, 0.032-inch-thick strip of brass can be soldered to the inside of the choke. This strip acts as a guide for adjusting the position of the choke, as illustrated in **fig. 3.** It also provides good electrical contact with the outer surface of the horn. Be sure the sliding surface is clean and free of paint and other insulating materials. Once the choke has been positioned for maximum gain, the outside surface of the horn and the choke can be sprayed with paint to protect these surfaces from the weather.

A typical 2304-MHz design uses a 4-inch (10-cm) diameter coffee can 5½ inches (14 cm) long with a 10-1/2 inch (26.7-cm) diameter choke. The choke is

1-1/4 inches (3 cm) from the open end of the horn. The probe (monopole) is located 2-3/8 inches (6 cm) from the shorted end of the horn. The improvement in gain due to the choke for this horn was 2.0 dB. VSWR was measured at less than 1.1 between 2.0 and 2.5 GHz.

The choke can also be made from 0.032-inch (0.8-mm) aluminum sheet stock. Cut the inside diameter 1-1/2 inches (4 cm) smaller than the OD of the horn. Serrate the hole with a saber saw or hacksaw blade to the horn diameter, then bend the tabs at right angles to match the contour of the horn. Cuts should be made every 20 degrees or so. Finally place a hose clamp over the tabs to provide both a good electrical and mechanical contact with the horn.*

adjusting the choke

A suggested test setup for adjusting the position of the rf choke for maximum feedhorn gain is shown in **fig. 5**. A signal generator or other rf power source drives a dipole illuminating antenna. The dipole should have a reflector as shown, and a balun might also be used to connect the unbalanced generator to the balanced dipole antenna terminals.

The horn antenna under test should be located at a distance from, and looking directly at, the illuminating antenna. A separation distance of 8 or 10 feet (2 or 3 meters) is generally satisfactory, although closer spacing may be necessary at higher frequencies. Orient the antennas so their polarizations match. Connect the output of the feedhorn to the input of a sensitive rf detector driving a microammeter or dc VTVM. If an rf amplifier is available, it can be inserted between the horn and rf detector to obtain greater measurement sensitivity. Another option is to connect the output of the feedhorn to the input of a converter and receiver combination; the receiver's S-meter can serve as the detector. In none of these situations is the radiation pattern of the transmitting antenna particularly critical, except that reasonable directivity is necessary to avoid reflections from nearby objects if the test is run indoors.

After having obtained a preliminary detector reading, slide the choke back and forth to identify the point that provides maximum detector current. Gain should be approximately 1.5 to 2.5 dB greater with the choke than without it. You can check this by removing the choke and noting the increase in generator output power necessary to recover the lost gain.

*Templates for several horn sizes are available from the author. Please state horn diameter and enclose $2.00 to cover the cost of printing and mailing.

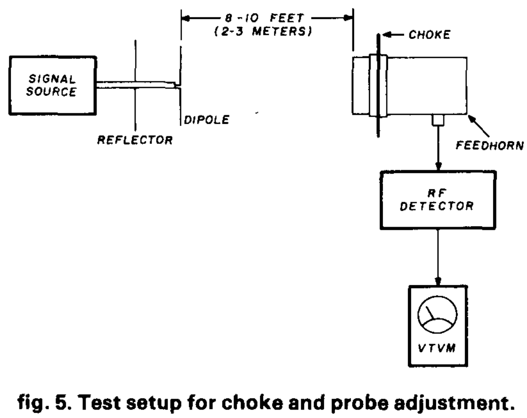


fig. 5. Test setup for choke and probe adjustment.

closing remarks

We Amateurs have known as far back as we can remember that the most simple and least expensive way to improve system performance is by increasing antenna gain. Because this is equally true for receiving and transmitting, any successful effort to improve the antenna is felt at both ends of the contact.

As we move from VHF to UHF in our quest for new experiences, we find that the parabolic antenna system is used more and more. While there are very few dishes in use at 432 MHz and below — other than at a few EME installations — fifty-three percent of all stations listed in the 1981 1296-MHz directory[7] who specified their antenna type are using parabolic reflectors. These range in size from 30 inches (0.75 meter) to 25 feet (7.6 meters) in diameter. The move to 2304 MHz will very likely see even greater use of the dish.

In my case, the need to stretch antenna performance to the limit in an effort to achieve "sparklie-free" TV images with the use of a very small parabolic reflector provided the impetus for improvement. It seems to me that Amateur EME and long-haul over the horizon (forward scatter) circuits stand to benefit also. I shall be delighted to hear from Amateurs and experimenters who prove this to be a correct hypothesis.

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A grounded, vertically polarized antenna with some interesting features

the half-delta loop

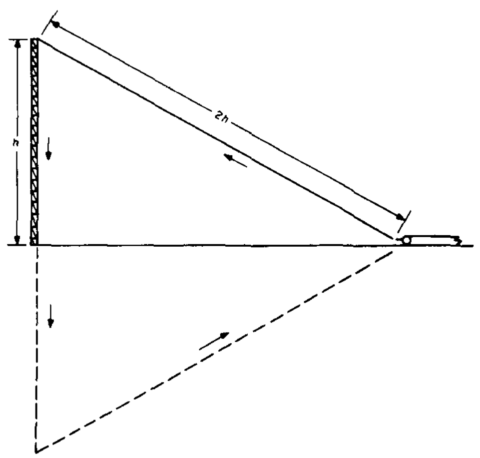

fig. 1. Grounded half-delta loop antenna and its image in the ground plane.

In a recent article on the half-sloper antenna,[1] I suggested that a half-delta loop configuration would make a better antenna system. That is, the sloping wire would be attached to the top of a grounded tower, and this wire would be end fed, against ground at its far end (see **fig. 1**). The length of the half-delta loop, including tower height plus length of the sloping wire would be an electrical half wavelength, but the loop is "full-wave resonant," if account is taken of its image in the ground plane. Obviously, characteristic of monopole grounded anten-

By John S. Belrose, VE2CV, 3 Tadoussac Drive, Aylmer (Lucerne), Quebec J9J 1G1, Canada

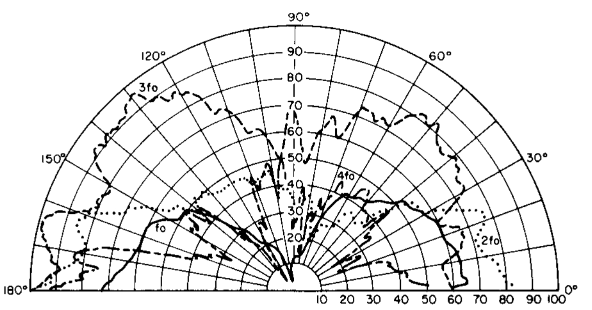

fig. 2. Vertical radiation pattern, vertical polarization, measured in the plane containing the half-delta loop, for the lowest resonant frequency (f_0) and for various harmonic frequencies ($2f_0$, $3f_0$, and $4f_0$).

nas, the half-delta loop will work best if a ground screen is used to improve the image that it sees of itself in the ground plane, and to provide a low resistance for return current flow in the ground to the grounded side of the coaxial feed. At the very least, a wire buried in the ground should connect the base of the tower to the shield of the coaxial feed cable, and two six-foot (2-meter) ground rods should ground the tower and the ground side of the feed.

design considerations

While other configurations will work, the antenna discussed here was arranged as a delta loop; that is, the antenna and its image have the shape of an equilateral triangle. Thus if the tower height is h, the length of wire should be $2h$, and therefore:

$$3h = k\lambda/2$$

$$h = \frac{k\lambda}{6}$$

where k is a factor greater than 1 that relates the physical and electrical lengths of the antenna. For the model antenna built for test and evaluation at a scale frequency of 200 MHz, k was experimentally determined to be about 1.12.

Thus the table below gives approximate dimensions for half-delta loop antennas for 160, 80, and 40 meters.

f (MHz)	tower height, h, feet	(meters)	length of sloping wire, feet	(meters)	band (meters)
1.8	100	(30.5)	206	(62.8)	160/80/40
3.6	50	(15.3)	103	(31.4)	80/40/30/20
7.15	25	(7.6)	52	(15.8)	40/20/15/10

Unlike dipoles, which are resonant at f_0, $3f_0$, $5f_0$, etc., the half-delta loop is resonant at all harmonics of its fundamental frequency f_0, $2f_0$, $3f_0$, $4f_0$, etc.

Measured radiation patterns for the modeled antenna, measured on the National Research Council, Ottawa, antenna pattern range,[1] are given in **figs. 2** and **3**. The curves in **fig. 2** show the vertical radiation pattern for vertical polarization, measured in the plane containing the antenna, at the lowest resonant frequency of the antenna, f_0, and for various harmonics of this frequency ($2f_0$, $3f_0$, and $4f_0$). While the polar pattern becomes more complicated at the higher harmonics, the antenna radiates essentially like a monopole antenna in that the polarization is vertical, and maximum gain is directed toward the horizon.

The curves in **fig. 3** show the azimuthal radiation patterns for vertical polarization for a launch angle of 10 degrees above the horizon, measured at these same frequencies. The polar pattern at the fundamental frequency is interesting; the antenna radiates in the plane broadside to it like two quarter-wave monopoles in phase. In this figure, the tower was located at the center of the polar diagram, and the delta loop had its apex directed toward the 0 coordinate. At harmonic frequencies the antenna exhibits a different directivity. The maximum gain occurs in the plane containing the antenna, rather than broadside to this plane, with the greatest gain in the direction away from the tower and its feed; and nulls appear in the plane broadside to the antenna — the nulls at $3f_0$ are particularly deep.

The vertical radiation patterns for horizontal polarization in the plane broadside to the half-delta loop

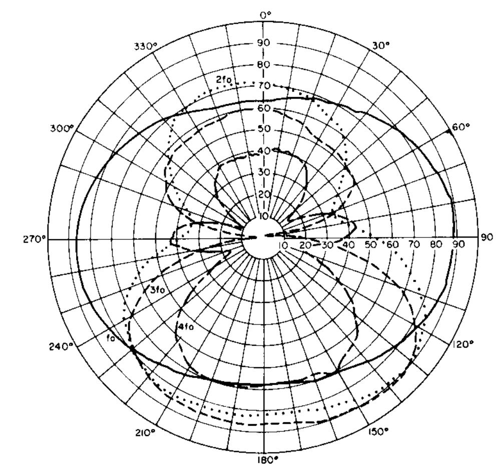

fig. 3. Azimuthal radiation pattern, vertical polarization, measured at an angle above the horizon of 10 degrees for the half-delta loop at its lowest resonant frequency (f_0) and for various harmonic frequencies ($2f_0$, $3f_0$, and $4f_0$). The delta loop was located at the center of the polar plot with its apex directed toward the 0-degree coordinate.

were also measured, and although these patterns are not shown, the horizontal field was small (especially at f_0 and $2f_0$). That is, the antenna radiates dominantly like a vertically polarized antenna.

The input impedance of the antenna, mounted on an aluminum sheet, was about 74 ohms at f_0, and the SWR was less than 2:1 at the second and third current mode resonances, which occurred at frequencies of 1.7 and 2.71 f_0 (that is, about 10 percent lower than exact multiples of the fundamental frequency).

influence of ground conductivity on the vertical pattern

While we have not calculated the pattern for antennas mounted on a finitely conducting earth, the effect is expected to be like that for a vertical monopole antenna. **Fig. 4** shows, for reference, calculated patterns for a quarter wave monopole antenna above earth having poor and good conductivity, compared with sea water, for 4 and 14 MHz.[2] The gain (greater than 2.15 dBi) comes about by the fact that a grounded monopole radiates into a hemispherical space, whereas a dipole antenna in free space radiates in all directions (over spherical space).

In concluding this brief discussion on the effect of the finite conductivity of the ground on the vertical radiation pattern of a vertically polarized antenna, and on the need to provide a ground screen beneath a current-fed grounded antenna, let me comment on a moot point not well understood. A radial ground screen beneath the antenna provides a low resistance path for the return current flow to the base of the antenna, or to the ground side of the coaxial feed in the case of the half-delta loop antenna. This is necessary to reduce the effective ground loss resistance, so that the antenna current contributes to radiation and not to ground loss. The ratio of the radiation resistance to the ground loss resistance referred to the feed point must be high for good radiation efficiency. However, to launch sky waves at a low elevation angle (less than 10 degrees) above the horizon, the ground conductivity fifty or more wavelengths in front of the antenna is important. As shown in **fig. 4** the effect of the conductivity of the earth is large, particularly at low angles, and the influence of the ground extends well beyond the limits of practical ground screens. This point was discussed in my subsequent article.[3]

The various patterns shown in **figs. 2** and **3** are relative. While no attempt was made to measure the gain of the antenna at the harmonic frequencies, it should be noted that the pattern for the *fundamental frequency*, f_0, was referenced to a half-wave dipole antenna one-quarter wavelength above the ground

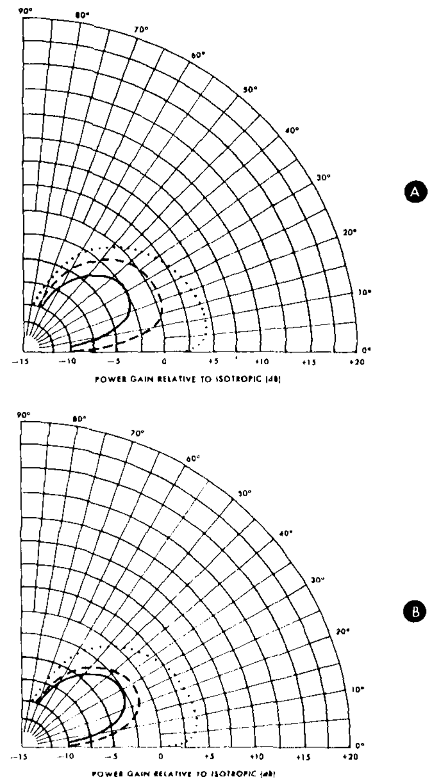

fig. 4. Theoretical vertical radiation pattern for a vertical quarter-wave antenna over three types of ground: poor (solid line), good (dashed line), and sea water (dotted line); calculated for two frequencies, 4 and 14 MHz, (A and B respectively). (Taken from reference 2.)

plane; and 45 on the relative-amplitude scale corresponds to approximately zero dBd. The antenna therefore exhibits a maximum gain approximately 6 dB over a dipole in free space.

acknowledgements

I wish to express my thanks to L.R. Bode of the Communications Research Centre, Department of Communications, Ottawa, who built the model antenna and measured its impedance, and to W. Lavrench (VE3LAV) and J.G. Dunn, who measured the antenna pattern on the National Research Council's (Ottawa) antenna pattern range.

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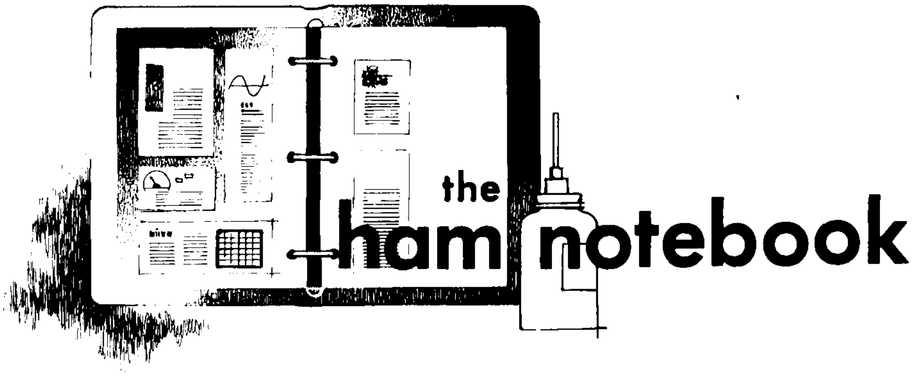

inexpensive automatic send/receive change-over relay

Many older tube transmitters using cathode keying can be retrofitted to provide inexpensive and automatic antenna send/receive change-over. All that's necessary is an antenna change-over relay controlled by the same circuit that grounds the final-amplifier tube cathode. However, unless one provides for a delayed release, the change-over relay "clunks" along with every depression of the key.

circuit

With the addition of a diode, a resistor, a large capacitor, and a sensitive relay (**fig. 1**), the initial depression of the key enables the antenna change-over relay as before, but the relay will not return to the receive position during subsequent code spaces until a short time delay has occurred. This time delay can be controlled by the sensitivity and dropout characteristics of the relay, and by the size of the capacitor. The delay can be made long enough to bridge spaces between characters, or even between words, with the proper choice of components.

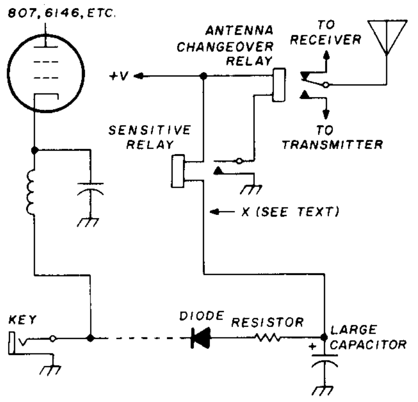

fig. 1. Inexpensive automatic send/receive change-over relay. Values for the diode, resistor and capacitor are discussed in the text.

operation

Assume that the key has been open for some time. The capacitor will have been charged to some positive voltage, there will be no potential difference across the sensitive relay to cause any current flow, and both relays will be de-energized (**fig. 1**). Closing the key will discharge the capacitor through the diode and the small series resistor (the resistor is included only to protect the diode by limiting the discharge current). This action will produce a potential difference across the sensitive relay, causing current to flow through it. Its closing then will activate the antenna change-over relay. If an additional contact on the antenna change-over relay controls the B+ to the transmitter final amplifier, this entire switching process will be completed by the time any rf power has been generated, and the normal load will be presented to the final amplifier.

When the key has been released, the diode will prevent leakage current through the tube from keeping the capacitor charged. (Note that the diode's PIV rating must be sufficient to withstand the key-up voltage at the cathode.) Thus, the capacitor will begin to charge from the current flowing through the sensitive relay. However, this current will keep the sensitive relay energized until the voltage across the capacitor has increased to the point that the potential difference across the sensitive relay is less than its dropout voltage (a relay's dropout voltage is always less than its pull-in voltage). If the key recloses before dropout occurs, then the capacitor will again discharge, and the cycle will repeat when the key is released. If the key remains open long enough (as at the end of the message), both relays will de-energize and reception again will occur.

additional notes

Since no internal connections to the transmitter are required, this change-over scheme can also be implemented as an outboard accessory. The relay can include contacts for more than antenna and transmitter power switching. Additional contacts can ground the receiver's antenna input, turn off the receiver's B+, turn on the linear's power, or dim the lights. In many cases the change-over relay may require a higher positive voltage than the sensitive relay (+12 volts versus +6 volts, for example); a dropping resistor may be inserted at point **X** in **fig. 1**.

final comments

The version of this circuit that I've retrofitted into two war-surplus TCS-13 transmitters used a junkbox rectifier diode, a 27-ohm, 1/2-watt resistor, a 1000-μF capacitor, and a small reed relay. The TCS-13 had *two* change-over relays. After the initial "ka-lunk," operation was blissfully quiet for about one second after the last key-down period, at which time a smaller clunk occurred, and the receiver was again operative.

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(Continued on page 42)

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modifications to the Atlas 350 AGC circuit

A renewed interest in CW and comments by Doug McDougall (*ham radio*, January, 1980, page 88) led to the following modification of an Atlas 350. The AGC characteristics remained unchanged whether operating CW or SSB. On CW, a shorter delay is desired, especially when operating QSK.

The original circuit used a 1-meg resistor as the discharge path for the AGC capacitor, C313. I decided that two resistors in series, one of which could be shorted out during CW, would allow two AGC time constants. The circuit (**fig. 2**) was developed and built onto a small piece of PC material, which was soldered to the ground plane of PC320, the AGC/AUDIO board. R1 and R2 replace R316, the 1-meg AGC resistor. R1 determines the CW response, while R2 was chosen to retain the original SSB response.

The **TUNE/CW-SSB** switch provides ground and a voltage to operate the circuit. On SSB a ground is pro-

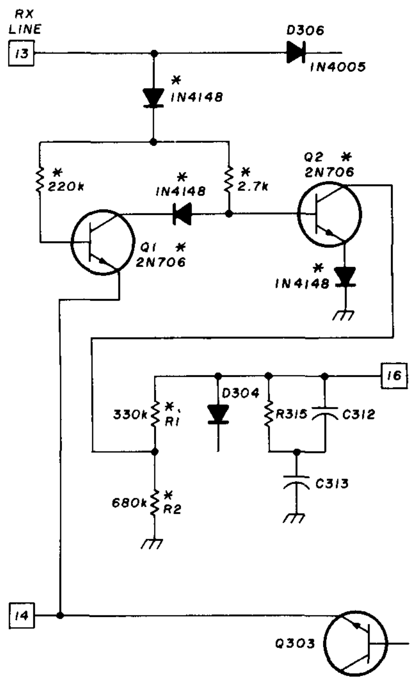

fig. 2. Modifications to the Atlas 350 AGC circuit for a shorter delay when in CW mode. Parts marked with an asterisk are added.

vided to Q1, which turns on, thereby turning Q2 off; R2 is now in the circuit. When in **TUNE/CW**, Q1 has a voltage applied to its emitter and therefore conducts less, allowing Q2 to turn on, placing its now small collector-emitter resistance in parallel with R2, which makes R1 the primary discharge resistance.

Performance is good, and I've noticed no degradation of operation.

Ron Lile, KØRL

tailoring audio response

This is an old idea with merit, but I've not seen it in print for some time. Listening to the receiver hiss during long periods of reception can be tiring. The audio response of a low-impedance speaker or phones may be tailored by adding an electrolytic capacitor of about 50 μF across the receiver speaker terminals or audio output jack. This cap will limit the audio high-frequency response and thus the hiss, making both CW and SSB reception more pleasant. Some overall attenuation will occur but it is relatively minor and can be compensated for by increasing the audio gain.

Paul K. Pagel, N1FB

antiflex coaxial cable connection

High onshore winds at my shack caused failure of my coax cable, the result of flexing where it emerged from the lower end of my antenna balun. I solved the problem by distributing the torque over a length of cable as shown in **fig. 3**. I used a length of fiberglass rod tip salvaged from a discarded fishing pole, which I attached to the balun with a 1.75-inch (4.4-cm) stainless-steel hose clamp. The cable was then taped to the rod as shown in the sketch. The tape was further secured by wrapping small-diameter nylon (not monofilament) line over the tape using a clove hitch. The line prevents the tape from loosening when the adhesive dries out. Finally, I covered the tape and twine with a generous coat of coil dope.

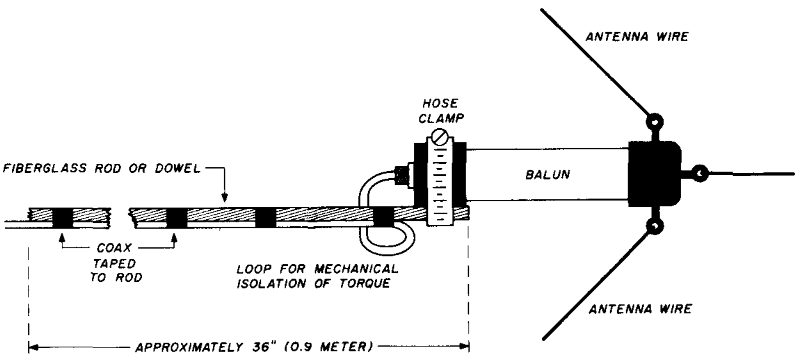

fig. 3. Method of securing coax cable to avoid failure from flexing.

While flexibility of the rod is important, a 1/4-inch (6-mm) length of maple dowel should do the job nicely if it's tapered down to about 3/16 inch (4.8 mm) at the lower end.

Lefferts A. McClelland, W4KV


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a Fresnel-zone plate for 10.4 GHz

An alternative to a parabolic reflector for your Gunnplexer transceiver

An increasing number of Radio Amateurs are stepping up to the 10.4-GHz Amateur band (10.0-10.5 GHz) to experiment with centimeter wavelengths and Gunn diode oscillators. The popular Gunnplexer transceivers offer the Amateur an excellent introduction to the 10.4-GHz band with a minimum of effort. (A recommended text is *The Gunnplexer Cookbook*, by Bob Richardson, W4UCH. It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $9.95 plus $1.00 shipping.)

The Gunnplexer uses a Gunn diode and a low-noise Schottky diode in a cavity that operates in the homodyne mode. The Gunn diode oscillates at the desired microwave frequency, which is the transmitted carrier frequency. The received carrier frequency is at some offset frequency (could also be the transmitted frequency that is returning to the Gunnplexer with some Doppler shift), which is mixed in a Shottky diode with the transmitted carrier frequency. The resulting i-f is then fed to a conventional high-frequency or VHF receiver for demodulation.

The common method of improving the performance of the Gunnplexer is the addition of a horn or

By William M. Brooks, WB6YVK, 2050 Southwest Expressway 66, San Jose, California 95126

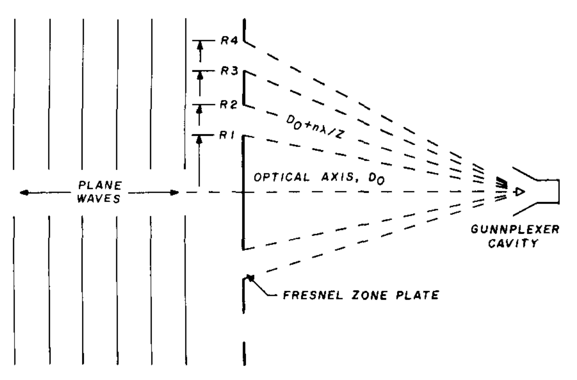

fig. 1. Geometry of the Fresnel-zone plate showing the relationship between the cut-out zones, which pass rf energy, and the center, or optical axis.

parabolic reflecting antenna to get some antenna gain. Some of the disadvantages of parabolic reflectors are that they are expensive, difficult to construct to the required tolerances, and difficult to mount or move because of their weight. This article describes an alternative antenna that yields results comparable to a parabola, yet is inexpensive and lightweight. Such an antenna is a Fresnel-zone plate.

description

The Fresnel-zone plate consists of a flat sheet of material that is opaque to 10.4-GHz energy (aluminum or copper foil) with concentric circular zones cut out to pass rf. The zones are spaced such that each zone is one-half wavelength greater in path length from the plate to the Gunnplexer cavity, out from the center zone, which is a straight-line path (**fig. 1**). The result is that each zone passes rf spaced one wavelength and adds constructively to the intensity of the rf at the focal point. The effect of the plate is to collimate the rf during transmit and focus it during receive, much like an ordinary optical converging lens.

geometry

To see how a Fresnel-zone plate works and to calculate the radii of the zones, refer to **fig. 2**. The outer edge of the nth zone is shown as R_n. According to the Fresnel diffraction theory, a wave that follows the path $L\text{-}R_n\text{-}F$ arrives $n\lambda/2$ out of phase with a wave that travels the path $L\text{-}O\text{-}F$. To express this mathematically, we say:

$$(S_n + S_0) - (d_n + D_0) = n\lambda/2 \qquad \textbf{(1)}$$

With a little trigonometry we find that:

$$S_n = \sqrt{(R_n^2 + S_0^2)} \qquad \textbf{(2)}$$

and

$$d_n = \sqrt{(R_n^2 + D_0^2)} \qquad \textbf{(3)}$$

and using binomial expansion yields

$$S_n = S_0 + \frac{R_n^2}{2S_0} \qquad \textbf{(4)}$$

and

$$d_n = D_0 + \frac{R_n^2}{2D_0} \qquad \textbf{(5)}$$

Substituting into **eq. 1** yields

$$\left(\frac{1}{S_0} + \frac{1}{D_0}\right) = \frac{n\lambda}{R_n^2}\ , \qquad \textbf{(6)}$$

which is identical to the thin-lens equation so familiar in classical geometrical optics.

In this case the wave source at L is at some great distance from the point 0, thus the waves incident upon the zone plate are very nearly plane-wave in shape. Hence S_0 approaches infinity and **eq. 6** reduces to

$$R_n^2 = nD_0\lambda \qquad \textbf{(7)}$$

A more precise equation can be derived from more terms in the expansion, which results in

$$R_n^2 + D_0^2 = (D_0 + n\lambda/2)^2 \qquad \textbf{(8)}$$

Thus, the radius of the nth zone is given by

$$R_n = \sqrt{nD_0\lambda + \frac{n^2\lambda^2}{4}} \qquad \textbf{(9)}$$

From the principle of reciprocity, during transmit a point source at F would produce an almost plane wavefront on the opposite side of the zone plate. The system thus behaves as a collimating and focusing lens for transmitting and receiving respectively.

The dimensions for an experimental Fresnel-zone plate of ten zones, with a focal length of 100 centimeters at 10.4 GHz are given in **table 1**. Note that the area of each of the zones is constant, thus each zone will contribute equally to the sum intensity at the focal point. Suppose that we construct a zone plate that passes only the odd zones and blocks the

table 1. Dimensions for an experimental Fresnel-zone plate of ten zones with a focal length of 100 cm at 10 GHz.

radius of zone 1	17.0453 cm
radius of zone 2	24.1918 cm
radius of zone 3	29.7339 cm
radius of zone 4	34.4548 cm
radius of zone 5	38.6564 cm
radius of zone 6	42.4930 cm
radius of zone 7	46.0561 cm
radius of zone 8	49.4047 cm
radius of zone 9	52.5800 cm
radius of zone 10	55.6115 cm

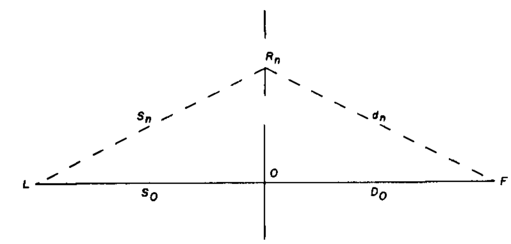

fig. 2. The Fresnel-zone plate is at O**, the Gunnplexer is at** F**, and the contact station is at** L**. When the contact station is at a large distance (more than 10 wavelengths), the distance** S_0 **approaches infinity, and the rf wave at** O **appears as a plane wave.**

even zones. The amplitude, E, at the focal point will be

$$E_T = E_1 + E_3 + E_5 + E \ldots + (2n-1) \quad (10)$$

If we construct a plate that passes the first 10 odd zones, the sum is $10\,E_1$. The incident wavefront gives $1/2\,E_1$, so the amplitude at the focal point, F, will be increased 20 times. The intensity is therefore increased 400 times, or 26 dB. Larger zone plates and greater gains are possible as long as the focal point aberrations are less than the depth of the Gunnplexer cavity.

construction

The first Fresnel-zone plate antenna I constructed was made from art matte board covered with aluminum foil and the radii cut out with a knife. Several "spokes" were left in the board to support the inner zones. Subsequent plates have been made with aluminum sheet metal. The resulting antenna has been tested with Doppler-shifted carriers and has confirmed the calculated focal length and gain.

It might be pointed out that modifications of the zone radii would make it possible to make a plate that was not flat and could thus be incorporated into the various shapes of aircraft or other vehicles. In either case, flat or otherwise, the dimensions required for a zone plate are not nearly as tight as those for a parabola, and the resulting antenna is much lighter.

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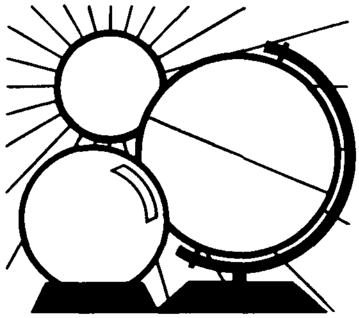

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The first of the month is expected to favor the lower frequencies for nighttime DX activities. DX conditions for the upper-frequency bands should improve during the third week, then round off and drop during the end of the last week. Solar radio flux is expected to be high during that time. Propagation disturbances from solar-flare activity of two to three days' duration are possible around the 15th and 25th. Also, a disturbed period may occur around the 5th from a coronal hole. Conditions will generally be poorer for hearing and working DX during these disturbances, but look for unusual DX locations to appear with weak, fading signals.

The lunar perigee, of interest to moonbounce DXers, will occur on the 24th of this month. An Aquarid meteor shower, of interest to meteor-scatter DXers, will show a maximum between May 4th and 6th, with a rate of 10 and 25 per hour for the Northern and Southern Hemispheres, respectively.

sporadic-E propagation

One of the major paths for excellent DX signals in the summer is short skip, or multiple short skips, on the higher frequency bands. Here we are in May, nearing summer. The end of May heralds the beginning of the sporadic-E (Es) propagation season. Es is a thin layer of intense ionization about 60 miles (100 km) above the earth. It gives rise to strong, mirror-like signal reflections over the short-skip distance of 600 to 1200 miles (1000 to 2000 km). Signals remain strong from a half hour to a couple of hours on the average, as the name sporadic suggests, rather than all day long or all night as with other high-frequency propagation.

The highest frequency propagated by Es follows the sun across the sky; the highest probability of occurrence, however, is near sunrise and again around sunset. These two facets of Es affect short-skip openings differently. Openings on the higher-frequency bands occur near local noontime and the lower bands tend to have openings near sunrise and sunset.

Now look at the best locations for these Es openings: since Es is related to the summer sun, the effect is in the Northern Hemisphere from June through September and in the Southern Hemisphere during their summer, December through March. The best Es is on either side of the geomagnetic equator; it's especially good where the geomagnetic equator has greatest separation from the geographic equator. These special areas are Southeast Asia in the Northern Hemisphere and South America in the Southern Hemisphere. The first is the best of the two because the E region ionospheric electric currents are strongest there. Another location of prolific Es for short skip is the auroral oval at about 20 degrees around the geomagnetic pole. This Es is not a summer phenomenon, though; it's mainly equinoctial. During geomagnetic disturbances, particles from the solar wind entering the polar regions penetrate to the E and F regions producing ionization (aurora) there. It is associated with auroral scatter VHF openings which intrigue DXers who work east/west paths to Europe and Japan using this mode.

To look for Es openings on the higher-frequency bands, monitor beacons on 6, 10, and 15 meters, WWV frequencies, and CB channel 19. Also check TV channels 2 through 5 for 6- and 2-meter openings. The lower bands don't need beacon monitoring, since Es openings (sunrise and sunset) are available most nights. Remember: couple your antenna to the ionosphere with takeoff angles of 5-10 degrees (see the January, 1981, DX Forecaster).

band-by-band summary

Six meters will provide very good openings during high solar flux to South Africa, Australia, and New Zealand around local noontime. Look for possible Es short-skip by monitoring TV.

Ten, fifteen, and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day, either long skip to 2500 miles (4000 km) or Es short skip to 1250 miles (2000 km) per hop. The length of daylight is now approaching maximum, providing hours of good DXing.

Forty, eighty, and one-sixty meters are the night DXer's bands. On many nights 40 meters will be the only usable band because of thunderstorm QRN, but signal strengths via Es short skip may overcome the static when Es is available. Although Es is scarcely available in May, it should be better next month.

ham radio

MAY

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GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PDT	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	—	—	—	15	15	15	15	15	20	20	20	20	20	20	20	20	20	—	—	—	—	—	—	—	N
EUROPE	20	20	—	—	15	15	15	20	20	20	20	—	—	—	—	—	—	20	20	20	20	20	20	20	NE
S. AFRICA	—	—	—	15	15	15	15	15	15	15	20	—	—	—	20	20	20	40	40*	40*	20	20	20	—	E
S. AMERICA	15	15	15	15*	15	15	10	10	15	15	20	20	20	20	20	20	20	15	15	15	15	10	10	15	SE
ANTARCTICA	10	—	—	—	—	—	—	—	—	40	40	40	40	20	20	20	20	20	20	15	15	15	15	10	S
NEW ZEALAND	10	10	10	10	15	—	—	—	—	20	20	20	20	20*	15	15	15	15	15	15	15*	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	15	—	—	—	—	20	20	20	20	15	15	15	15	15	15*	15*	10	10	10	10	W
JAPAN	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20	20	20	20*	20*	15	15	15	15	15	NW

MID USA

MDT	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	
ASIA FAR EAST	—	—	—	—	15	15	15	20	20	20	20	20	20	20	20	20	—	—	—	—	15	15	15	—	N
EUROPE	20	20	15	15	15	15	15	15	15	20	20	20	—	—	—	—	—	20	20	20	20	20	20	20	NE
S. AFRICA	—	—	—	—	15	15	15	15	15	15	15	—	—	—	—	20	20	20	40	40	40	20	20*	15	E
S. AMERICA	10	10	10	10	10	10	15	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15*	15	SE
ANTARCTICA	15	10	10	—	—	—	—	—	—	—	—	—	40	40	40	20	20	20	20	20*	15	15	15	15	S
NEW ZEALAND	10	10	10	15	15	15	—	—	—	—	20	20	20	20	20	20	20	20	15	15	15	15*	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	15	—	—	—	—	—	20	20	20	20	20	20	15	15	15	15	15	15	10	10	W
JAPAN	15	15	15	—	—	15	15	15	20	20	20	20	20	20	20	20	20	20	20	15	15	15	15	15	NW
CDT	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	

EASTERN USA

EDT	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	
ASIA FAR EAST	15	15	—	—	15	15	15	20	20	20	20	—	—	—	—	—	20	20	20	20	—	—	15	15	N
EUROPE	15	15	15	15	15	15	15	15	15	15	—	—	20	20	20	20	20	20	20	20	20	20	20	20	NE
S. AFRICA	10	10	10	15	15	10	10	10	15	15	15	15	—	—	—	—	20	20	20	40	40	40*	20	15	E
CARIBBEAN S. AMERICA	15	15	15	15	10	10	10	10	15	15	20	20	—	—	—	—	20	20	20	20	15	15	15	15	SE
ANTARCTICA	15	15	15	15	—	—	—	—	—	—	—	—	—	40	40	40	40	40	20	20	20	20	20	20	S
NEW ZEALAND	15	15	15*	15*	15	—	—	—	—	20	20	20	20	20	20	20	20	20	20	—	—	15	15	15	SW
OCEANIA AUSTRALIA	10	15	15	15	—	—	—	—	—	—	20	20	20	20	20	20	20	20	20*	15	15	15	15*	10	W
JAPAN	15	15	20*	20	15	15	—	—	—	20	20	20	20	—	—	—	—	—	—	—	20	20	20	15	NW

*Look at next **higher** band for possible openings.

Dyna-"mite."

Photo shown is TR-7730 in 16-key autopatch UP/DOWN microphone version.

Miniaturized, 5 memories, memory/band scan

TR-7730

The TR-7730 is an incredibly compact, reasonably priced, 25-watt, 2-meter FM mobile transceiver with five memories, memory scan, automatic band scan, and other convenient operating features. The TR-7730 is available in two variations: a 16-key autopatch UP/DOWN microphone (MC-46) version, and a basic UP/DOWN microphone version.

TR-7730 FEATURES:

- **Smallest ever Kenwood mobile**
  Measures only 5-3/4 inches wide, 2 inches high, and 7-3/4 inches deep, and weighs only 3.3 pounds. Mounts even in the smallest subcompact car, and is an ideal combination with the equally compact TR-8400 synthesized 70-cm FM mobile transceiver.
- **25 watts RF output power**
  HI/LOW power switch selects 25-W or 5-W output.
- **Five memories**
  May be operated in simplex mode or repeater mode with the transmit frequency offset ±600 kHz. The fifth memory stores both receive and transmit frequency independently, to allow operation on repeaters with nonstandard splits. Memory backup terminal on rear panel.
- **Memory scan**
  Automatically locks on busy memory channel and resumes when signal disappears or when SCAN switch is pushed. Scan HOLD or microphone PTT switch cancels scan.
- **Automatic band scan**
  Scans entire band in 5-kHz or 10-kHz steps and locks on busy channel. Scan resumes when signal disappears or when SCAN switch is pushed. Scan HOLD or microphone PTT switch cancels scan.
- **Extended frequency coverage**
  Covers 143.900-148.995 MHz in switchable 5-kHz or 10-kHz steps.
- **UP/DOWN frequency control from microphone**
  Manual UP/DOWN scan of entire band in 5 kHz or 10 kHz steps is possible when using either autopatch or basic UP/DOWN microphone versions.
- **Offset switch**
  Allows VFO and four of five memory frequencies to be offset ±600 kHz for repeater access or simplex.
- **Four-digit LED frequency display**
  Indicates receive and transmit frequency.
- **S/RF bar meter and LED indicators**
  Bar meter of multicolor LEDs shows S/RF levels. Other LEDs indicate BUSY, ON AIR, and REPEATER offset.
- **Tone switch**

Optional accessories:

MC-46 16-key autopatch UP/DOWN microphone
SP-40 compact mobile speaker
KPS-7 fixed-station power supply

More information on the TR-7730 and TR-8400 is available from all authorized dealers of Trio-Kenwood Communications
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TR-8400

- **Synthesized coverage of 440-450 MHz**
  Covers upper 10 MHz of 70-cm band in 25-kHz steps, with two VFOs.
- **Offset switch**
  For ±5 MHz transmit offset on both VFOs and four of five memories, as well as simplex operation. Fifth memory allows any other offset by memorizing receive and transmit frequencies independently.
- **DTMF autopatch terminal**
  On rear panel, for connecting DTMF (dual-tone multifrequency) touch pad (for accessing autopatches) or other tone-signaling device.
- **HI/LOW RF output power switch**
  Selects 10 watts or 1 watt output.
- **Virtually same size as TR-7730**
  Perfect companion for TR-7730 in a compact mobile arrangement.
- **Other features similar to TR-7730**
  Five memories, memory scan, automatic band scan (in 25-kHz steps), UP/DOWN manual scan, four-digit LED receive frequency display (also shows transmit frequency in memory 5), S/RF bar meter and LED indicators, tone switch, and same optional accessories.

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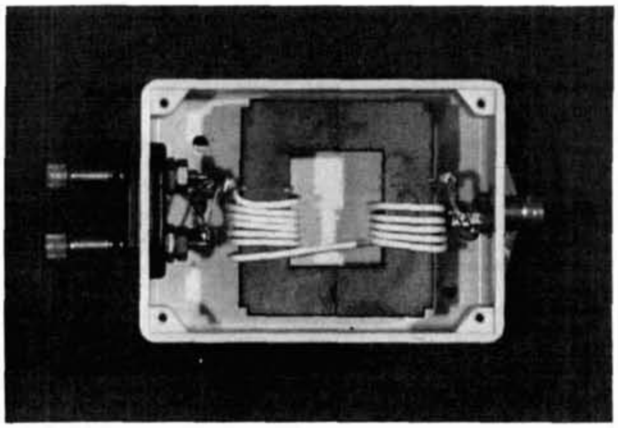

another balun design

Discarded TV-set flyback transformer cores can be made into broadband baluns at minimal cost

Modern Amateur equipment is designed for unbalanced coaxial-cable output. The proper way to connect this gear to a balanced load, such as a dipole antenna, is to place a balancing network, or *balun*, between the coax transmission line and the antenna. The balun ensures proper operation of the antenna, prevents antenna currents from appearing on the coax-cable shield, and keeps rf voltages from appearing on the outside of the rig.

Theoretically, baluns can be constructed for any given impedance transformation, but standard transformation ratios are 1:1 and 4:1. The 1:1 balun transforms a 50-ohm unbalanced coax transmission line, for example, to a balanced 50-ohm load, or a 75-ohm unbalanced line to a 75-ohm balanced load. The 4:1 balun may be used to transform 300-ohm balanced line, such as twinlead, to a 75-ohm unbalanced coax line.

the flyback balun

Many balun designs have been described in the Amateur literature. The two designs presented here are in no way unique except in their use of ferrite cores from old TV-set flyback transformers.

Any discarded TV set has a flyback transformer (sometimes known as a horizontal-output transformer). This transformer, which has a ferrite core, is designed to operate at the horizontal sweep frequency of 15.75 kHz, and must handle harmonics extending to 1 or 2 MHz. The transformer is easy to disassemble, as the ferrite core is always in the form of two U-shaped halves. High-Q coils for low or medium frequencies can be made from this high-permeability ferrite, but in the upper high-frequency region, the core material is too lossy to form coils of any appreciable Q. This fact has probably deterred Amateurs from using these cores for baluns. (One exception is W6SJQ's article, "Three Baluns for a Buck," *73* magazine, August, 1979, page 102.) However, the baluns described here don't require high-Q ferrite cores for their performance. This is because, at high frequencies, the magnetic field does not penetrate very far into the core, so core losses remain small.

the 4:1 balun

Essentially, the 4:1 balun consists of a pair of two-wire transmission lines wound into coils as shown in **fig. 1**. The air-core version of this type of balun was known as "elevator coils" in the early days of television. Its operation can be understood if we assume for the moment that both lines are of 100-ohm characteristic impedance and without standing waves. Since the two 100-ohm lines are connected in parallel at the input, they will be matched to 50-ohm coax. At the output, however, the two 100-ohm lines are connected in *series* to produce 200 ohms, balanced to ground. The purpose of the ferrite cores is to give the bifilar coils enough inductance to isolate the input from the output and prevent a low-impedance path across the input or output terminals.

By Fred Brown, W6HPH, 1169 Los Corderos, Lake San Marcos, California 92069

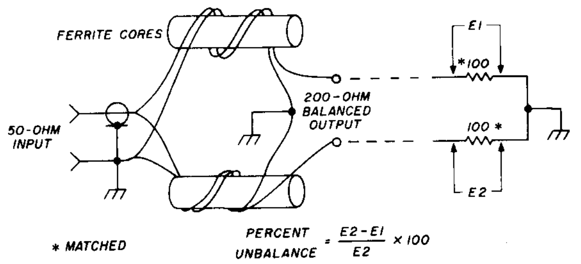

fig. 1. The basic 4:1 balun consists of two ferrite cores wound with 100-ohm (or 150-ohm) transmission lines. The air core version is known in the TV industry as "elevator coils." At the right is shown a method of determining the degree of unbalance at the output terminals by measuring the rf voltage across matched 100-ohm resistors.

The transformation of 75-ohm coax to 300-ohm twinlead ideally would require bifilar coils wound with 150-ohm transmission lines. Since neither 100- nor 150-ohm twinlead was available, the 4:1 balun coils were made with No. 24 (0.5 mm) vinyl zip cord. This wire is readily available in retail stores; often it is sold as "speaker wire." *Q*-meter measurements indicate its characteristic impedance to be about 156 ohms.

Vinyl, unfortunately, is quite lossy at radio frequencies. A better choice would have been twisted pair made of Teflon or polyethylene insulated wire. Ideally, the insulation should be of a thickness that give a characteristic impedance in the vicinity of 100 or 150 ohms, but below VHF the impedance is not particularly critical because the lines are short in terms of a wavelength. Another possibility is 72-ohm receiving twinlead.

Construction details are shown in the photograph. The size of the flyback transformer core is not particularly important; the one used here had a cross-sectional diameter of about 5/8 inch (16 mm). The two bifilar coils are twelve turns each; they should be wound in the same direction and should be as identical as possible. The coil ends can be anchored to the ferrite with epoxy cement. Leads to the input and output connectors should be short and of equal length for both coils. When wound, the two cores can be fastened to the wooden base by cementing the core faces to the wood with epoxy or super glue. If a metal box is used, the core faces should be spaced away from the metal by nonmetallic spacers of at least a few millimeters thickness.

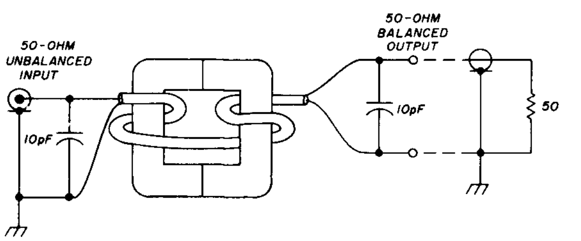

fig. 2. The 1:1 balun is a short length of small-diameter coax wound on a ferrite core. A severe test for insertion loss with this type of balun is to connect an unbalanced load the "wrong way" to the balanced output, as shown.

1:1 balun

The basic design of the 1 to 1 balun, **fig. 2**, has been described previously by Joe Reisert, W1JR.[1] This is a "choke" type of balun: a magnetic core wound with small-diameter coax. Losses are very low in this type of balun, and it is ideal for connecting coax to a dipole antenna.

The toroidal ring is formed by cementing together the two U-shaped halves of the flyback transformer core. The coaxial coil is wound in two halves on opposite sides of the core; each half is six turns. Be sure to adhere to the winding direction shown in **fig. 2**. The ends can be secured to the core by tying with short lengths of nylon fishline.

The balun shown was wound with RG-196A/U 50-ohm coax; if 75 ohms impedance is desired, RG-187A/U is recommended. In either case, since the dielectric is Teflon rather than polyethylene, the power-handling capacity of this smaller coax is the same as RG-58 – about 400 watts at 30 MHz. For Amateur use this means the legal power limit below 30 MHz, because the duty cycle for CW is only 50 percent, and your kilowatt final is not going to exceed 80 percent efficiency. (Just don't hold that key down too long!) SSB has an even lower duty cycle. If RG-174/U is used the power rating will have to be reduced to 100 watts continuous at 30 MHz.

results

When the baluns were properly terminated, input SWR measured less than 1.1 on all bands, 160 through 10 meters. Measured insertion loss is given in **fig. 3**. Accurate measurement of insertion loss in the 1/10 dB area is never easy, but these curves are believed to be fairly accurate. The 4:1 balun has a power loss of 6.4 percent at 29 MHz. When 200 watts of rf were run through this balun, the zip cord became warm to the touch, revealing that the vinyl insulation was the cause of the power loss. Two hundred watts is about the maximum continuous power that the zip cord will handle at 10 meters, although higher power could be run intermittently, or at lower frequencies. As mentioned before, much better performance could be expected from Teflon-insulated

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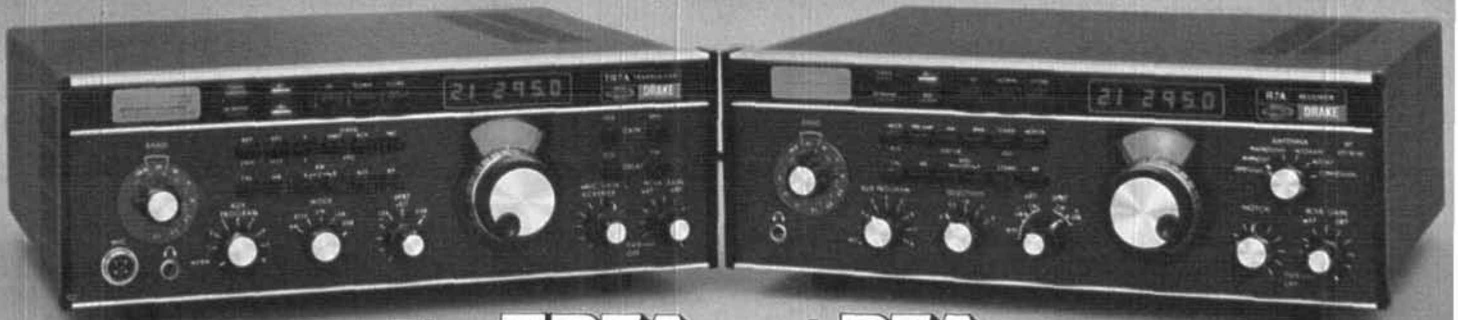

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• **Full Passband Tuning (PBT)** enhances use of high rejection 8-pole crystal filters.

New! **Both 2.3 kHz ssb and 500 Hz cw crystal filters, and 9 kHz a-m selectivity are standard,** plus provisions for two additional filters. These 8-pole crystal filters in conjunction with careful mechanical / electrical design result in realizable ultimate rejection in excess of 100 dB.

New! **The very effective NB7 Noise Blanker is now standard.**

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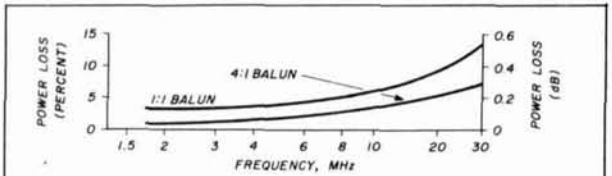

fig. 3. Measured insertion loss versus frequency for the two baluns. Percentage power loss is shown on the left hand scale, dB at right.

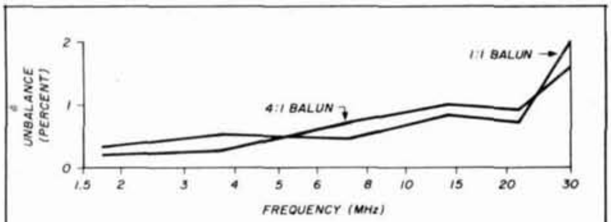

fig. 4. Measured percentage unbalance for the two baluns, measured across a balanced resistive load, as shown in fig. 1.

twisted pair. Insertion loss of the 4:1 balun measured 1 dB at 6 meters and about 3 dB at 2 meters.

The excellent results on 160 meters indicate that fewer turns could have been used on both baluns, which would reduce losses on the higher bands without much sacrifice of performance on 80 or 160 meters.

The 1:1 balun's insertion loss was measured by Joe Reisert's acid test; that is, by connecting the balanced output to an ordinary unbalanced-input wattmeter, with the *inner* conductor of the balun going to the *outer* conductor of the load, and *vice versa* (see **fig. 2**). As a result, most of the power loss shown in **fig. 3** is radiation loss — not heat loss in the balun itself.

Initially the 1:1 balun showed an insertion loss of 3.5 dB on 2 meters. This high value was traced to reflections from the inductance of the half-inch-long leads that connect the RG-196 to the input and output connectors. The loss was decreased to 1 dB by soldering 10-pF capacitors, with the shortest possible leads, directly across the connectors.

Fig. 4 shows the degree of unbalance: $\frac{E2 - E1}{E2}$, expressed in percent and measured for both baluns by the split-load method shown in **fig. 1**. Two matched 25-ohm resistors were used for the split load on the 1:1 balun.

reference

1. Joe Reisert, W1JR, "A Simple and Efficient Broadband Balun," *ham radio*, September, 1978, page 12.

ham radio

antenna geometry for optimum performance

Design considerations in terms of path distance, ionospheric height, and antenna height

If you had your choice of a 10-dB-gain antenna at 40 feet (12 meters) or a 5 dB-gain antenna at 120 feet (37 meters), which would you choose? Presumably, there would be a split decision on such a question. However, the real reply would be that the question does not provide enough data to properly make a sound decision. Antenna gain or antenna height are secondary considerations in antenna design. *The primary objective in an antenna design is to provide maximum signal energy at the desired receiving location.* This is done by providing the most favorable radiation pattern in both the horizontal and vertical planes to match the conditions of a very unstable propagation medium, the ionosphere.

This article discusses the important relationship of the vertical radiation angle of an antenna, height of the ionosphere, and distance between the transmitter and the receiver. As to the opening question, it will simply be stated now that the high-gain antenna on 20 meters would be superior for domestic operations. The 120-foot (37-meter) low-gain antenna would always beat out the higher-gain antenna for maximum distance, world-wide contacts.

ionospheric reflections

High-frequency propagation occurs between the surface of the earth and one or more layers of ionized atmosphere that exhibit sufficient conductivity to reflect the radio signals back to earth. One reflection from the ionosphere is called one hop, and the number of hops made by the radio wave before arriving at the receiving location is the number of successive reflections from the ionosphere. These are called multihop transmissions. Single and multihop propagation can occur simultaneously.

Propagation can be further complicated by reflections from more than one conductive layer. **Fig. 1** is a simple flat-earth representation of a radio circuit showing reflections from the E, F_1, and F_2 layers of the ionosphere. Single-hop transmissions are shown by the solid lines and two-hop transmissions by a dashed line.

Consider the multiple path signals, both one and two hop, arriving at the receiver due to reflections from the E, F_1, and F_2 layers. Such a situation could exist if there is a broad vertical lobe of radiant energy from the transmitting antenna. The path length of the different signals, as well as the height change with time of the three layers, will cause the signals to arrive at the receiver at different times; that is, the signals will not all be in phase. Such a situation will cause fading of the received signal with loss in quality of the communications circuit.

One may eliminate the E-layer reflection completely by choosing a frequency high enough to penetrate the E layer at any vertical angle of radiation. If the frequency is close enough to the maximum usable frequency (MUF) and F_2 is controlling, then F_1 reflection may be absent, or very small. In such a case, the remaining conflicting wave arrivals would be from a one and two-hop reflection from the F_2 layer. How-

By Henry G. Elwell, Jr., N4UH, Route 2, Box 20G, Cleveland, North Carolina 27013

ever, if it happens that the large angle of incidence at A and C of **fig. 1** caused the waves at these points to penetrate the F_2 layer without reflection, only the one-hop F_2 signal would arrive at the receiver at maximum strength with no fading. Elimination of the two-hop path could also occur by restricting the vertical radiation energy to a low angle of fire.

At the other extreme, the operating frequency could be chosen so low that the signal would not penetrate the E layer at all, thus eliminating the F_1 and F_2 reflections. However, there may remain multipath E-layer signals unless the antenna radiation patterns at transmitting and receiving locations provide very low response at the higher angles at which multipath E-layer signals could be propagated.

The known methods of attack on the multipath problem involve these factors:

1. Use a frequency that will cause reflection from one layer only, as nearly as possible.

2. Use a frequency that will require reflection at the lowest angle of incidence possible, such that higher angle radiations will penetrate the layer and not be reflected.

3. Use a directive antenna that will focus the angle of one dominant wave group and discriminate against other multipath signals by relatively low response to all other angles.

On one-hop circuits it might be relatively easy to apply any one or all three of the above principles for reducing multipath circuits. However, on multihop circuits different ionosphere characteristics occur at each point of reflection. Also it is necessary to use a frequency that is a limiting factor at one of the reflection points. Therefore, it is more difficult to adhere to those ideal principles for multihop paths.

is highest gain and height always best?

High antenna gain and high antenna height seem to be the dominant factor in today's selection of antenna systems. That philosophy without further thought to the overall consequences is all right if your goal is to put the strongest signal at the greatest distance at any particular time of the day. Don't be upset, however, if your signal is *less than average* at medium ranges during the daylight hours.

The strength of your transmitted signal received at a distant point, at any time of the day, is a function of your power, antenna gain, antenna height, atmospheric absorption factors, and the height of the ionosphere. Let's eliminate power, antenna gain, and absorption in the following discussion. Power and absorption are independent of the antenna system, and

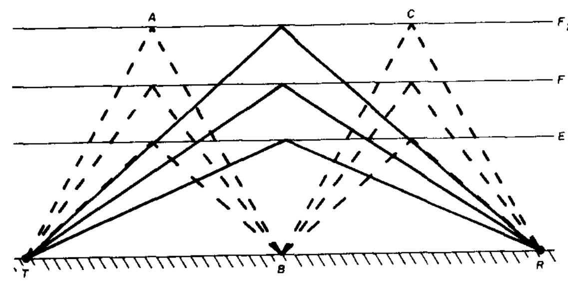

fig. 1. Flat-earth representation of a radio circuit showing reflections from the E, F_1, and F_2 layers for a one-hop and two-hop transmission.

the antenna gain, while important, does little good if the signal does not come down at the desired location.

the propagation-distance formula

The following equation relates the vertical angle of radiation from the antenna and the height of the ionosphere, to the distance between the transmitted signal and the point the signal returns to earth; that is a one-hop occurrence. (The derivation of the equation may be found in the appendix.)

$$D = 222.26 \left\{ \cos^{-1} \left[\frac{\cos \alpha}{(1 + 0.000157\, h_i)} \right] - \alpha \right\} \quad \textbf{(1)}$$

where D is the surface distance between the transmitting antenna and the first reflected return to earth in kilometers, α is the vertical radiation angle of the antenna in degrees from the horizon, and h_i is the height of the ionosphere in kilometers.

If you have a calculator with "*cos*" and "inverse *cos*" functions, the equation is easy to solve. However, **fig. 2** shows the equation pictorially for various heights of the ionosphere.

The use of the chart is quite simple. Enter the left side of the chart with the known vertical angle of radiation of your antenna. Go horizontally to the right until an intersection with a curve of the desired ionosphere height is met. Then drop down vertically and read the distance scale on the bottom of the chart.

Example. Known: Vertical angle of radiation is 30°. Ionosphere height is 400 km. Distance: 1206 km for one-hop transmission.

height of ionosphere

You say you don't know the height of the ionosphere or the vertical angle of fire of your antenna? OK, let's consider the ionosphere's height, and then we'll spend some time on the vertical radiation problem.

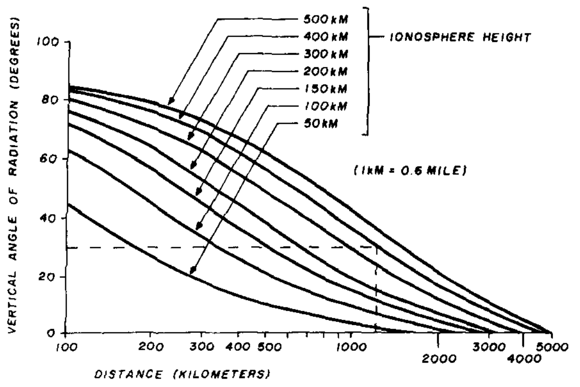

fig. 2. Vertical angle of radiation as a function of distance with ionosphere height as a parameter. An example is given for a vertical radiation angle of 30° and an ionosphere height of 400 km; the distance for a one-hop transmission is 1206 km.

The height of the ionosphere layers varies with latitude, with the hour of the day and the seasons, and with sunspot activity. Over the earth on any particular day, the variations of height are of the order of 2 to 1. Monthly average heights at any one location, however, usually follow a fairly constant pattern.

In some older texts, typical heights were assigned to the layers, but such rough information may be misleading. The Central Radio Propagation Laboratory, when at the National Bureau of Standards, Washington, D.C., used to publish monthly reports on details of various ionosphere heights, but that information has been discontinued. However, we do know the bands of ionosphere heights that will give us sufficient information to make our distance calculations; see table 1 for most intensely ionized regions. These bands of ionosphere heights will be used to show how the distance transmitted for a given vertical radiation angle changes from dawn to noon, for example, as shown in **table 1**.

vertical radiation angle

The vertical radiation angle of a horizontal antenna is easy to determine. Keep in mind that the vertical radiation of most horizontal antennas is a function only of its height above ground; this includes dipoles, Yagis, and other horizontally polarized, single-level beams. The number of elements in a Yagi, for example, does not change its vertical radiation angle. The radiation pattern in the vertical plane perpendicular to the wire of the antenna is given by the equation:

$$F(\alpha) = \sin (h \sin \alpha) \qquad \textbf{(2)}$$

where α is the vertical angle of radiation from the horizon
h is the height above ground in electrical degrees

The equation is meant for radiation over perfectly conducting ground. However, it is used for pattern work for typical imperfectly conducting grounds such as are encountered in practice.

The value of α for maximum signal at any given height, is when $F(\alpha) = 1$, since a sine function varies from a maximum of 1 to a minimum of 0. The latter factor, 0, means that there will be a null in the vertical radiation at some point.

The workable equation is (see the appendix for derivation):

$$h_{ft} = \frac{\sin^{-1} F(\alpha)}{0.366 f \sin \alpha} \qquad \textbf{(3)}$$

where: h_{ft} is the height of the antenna in feet
α is the vertical angle of radiation from the horizon for the antenna
f is in MHz

$F(\alpha)$ is 0 or 1, or as we will see later, any number in between such that $\sin^{-1}(1)$ is 90° for first lobe, 270° for second lobe, 450° for third lobe, etc., and $\sin^{-1}(0)$ is 180° for first null, 360° for second null, 540° for third null, and so on.

The solution of this equation with antenna vertical radiations of 90° to 1°, to give corresponding antenna heights for the first lobe at each frequency band, was done on a programmable calculator; doing it manually is a terrible job. Solution of antenna height was preferred over solving for vertical radiation angle because of the limits of 0° to 90° expected from an antenna pattern; antenna height can be from 0 to infinity theoretically.

The graph of the results is shown on **fig. 3**. That curve is very interesting so let's test it. You have your beam at an 80-foot (24-meter) level and are operating it on the 20-meter band. Enter the curve at the bottom for antenna height of 80 feet (24 meters) and go up vertically until you intersect the 20-meter antenna operating band. At that point go to the left horizontally and determine that the vertical angle of radiation for the antenna is 12.7°. The results for all Amateur bands for an 80-foot (24-meter) tower is shown in **table 2**.

table 1. Height of ionosphere.

layer	summer day (km)	winter (km)	night (km)
E	110 - 130	110 - 130	— —
F_1	280 - 310	210 - 250	275 - 325
F_2	450 - 480	270 - 320	— —

table 2. Vertical radiation angle for all bands with antenna height of 80 feet (24 meters).

frequency band (MHz)	vertical radiation angle first lobe (degrees)	first null (degrees)
1.90	(note 1)	–
3.80	54.0	(note 2)
7.25	25.0	58.0
10.25	17.5	37.0
14.20	12.7	25.5
18.10	9.8	20.0
21.25	8.2	17.0
24.94	7.0	14.2
28.50	6.2	12.5

(1) 90° is achieved by an antenna 136 feet (41.5 meters) high.
(2) 90° is achieved by an antenna 129 feet (40 meters) high.

Table 2 should be studied carefully by one-tower owners who like to "Christmas-tree" monobanders for different bands. Such towers usually have the 40-meter beam at the lowest height, then the 20-meter beam is higher, followed by the 15-meter beam, and the 10-meter beam on top. From a propagation standpoint, isn't that the reverse order? I always put the 40-meter beam on top to give it the lowest vertical radiation angle for the available height with the 10-meter beam on the bottom. The 10-meter beam automatically has a reasonable wavelength-height, hence a reasonably low vertical angle of radiation. It's the 40-meter beam that needs the highest location. That of course requires proper consideration for structural integrity.

For you 160-meter enthusiasts, **table 2** shows why a horizontal antenna on that band will be very poor for DX work. Even at 136 feet (41.5 meters) high, it is putting out a vertical radiation angle of 90°. Put your effort and wire into a vertical antenna for DX on 160 meters.

Although an 80-foot (24-meter) high antenna on 80 meters is probably better than the run-of-the-mill on that band, you will still do better with a properly constructed vertical for DX work.

vertical radiation null angle

The second consideration for the antenna height is, "Where are the nulls going to fall?" By making $F(\alpha) = 0$, such that $\sin^{-1} F(0) = 180°$, the first null can be determined. These values are also shown in **table 2**.

As you can see, **fig. 3**, showing the first lobe for all Amateur bands makes for a pretty busy graph. To show the additional lobes plus nulls would be a disaster. However, all bands for lobes and nulls up to the seventh is easily shown if height above ground is in electrical degrees. **Fig. 4** shows such a curve. To use the curve a calculation is necessary for the height and frequency for which you are interested (see the appendix for proof).

$$h = 0.366\, h_{ft} f \qquad (4)$$

where: h = height above ground in electrical degrees
h_{ft} = height in feet
f = MHz

Let's say you want to find the lobes and nulls for your 100-foot (30.5-meter) high tribander at 10, 15, and 20 meters. Solution of the equation for h for each band and subsequent use of **fig. 4** would give the results in **table 3**. You might ask the question, "Why bother about the null? There's nothing there anyway, so forget it!" There may be plenty "over there" where your signal is nulled out, and you should at least know about it even though you intend to ignore it. It may be just the knowledge you need to design for a different height or provide for a lower-height antenna to fill in the nulled area.

vertical radiation polar diagrams

Let's look at another representation of maximum (lobes) and nulls: the vertical polar radiation diagrams. See **fig. 5**, which is the 14.2-MHz plot of the 100-foot (30.5-meter) antenna. The same data is being used as in **table 3**. You have seen these in antenna books many times I'm sure. If you are like I am, you may have wondered how they determine their shape. Well, **fig. 5** was calculated and then plotted using the same $F(\alpha) = \sin(h \sin \alpha)$ equation as before.

All you do is select the height of the antenna you want, in feet, change that to electrical degrees, h, for the frequency desired, and solve the equation for dif-

table 3. Nulls/lobes for tribander at 100 feet (30.5 meters).

band (MHz)	height (electrical degrees)	radiation angle (degrees) first lobe	first null	second lobe	second null	third lobe	third null	fourth lobe	fourth null	fifth lobe	fifth null
14.2	520	10.0	20	31	44	60.6	–	–	–	–	–
21.3	780	6.5	13	20	28	35.0	43	52	68	–	–
28.5	1043	5.0	10	15	20	25.5	31	37	43	50	58

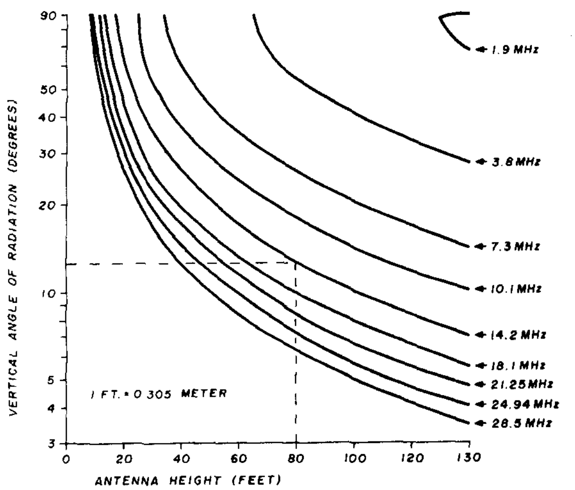

fig. 3. Vertical radiation angle as a function of height for horizontal antennas with frequency as a parameter. Example shows that an antenna height of 80 feet (24 meters) will produce a vertical radiation angle of 12.7° on the 20-meter band.

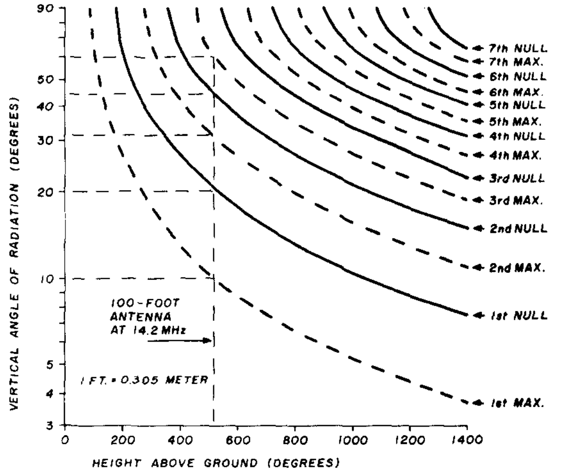

fig. 4. Vertical radiation angle as a function of antenna height in electrical degrees showing angles of maximum radiation and nulls for use on all bands.

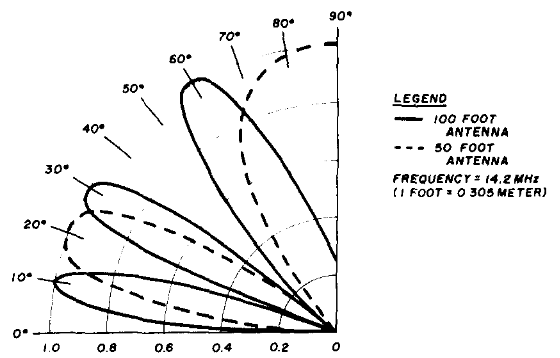

fig. 5. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled by the lower antenna (frequency is 14.2 MHz).

ferent values of vertical angle of radiation, α, from 90° to 0°. This will give you the left side of the figure. If you use α equal to 180° to 0°, you get the complete radiation pattern for a dipole. However, one side is a mirror image of the other, and a beam antenna would be attenuated on the back side anyhow; use 90° to 0°.

These calculations are very easy using a programmable calculator when you program it to decrement automatically by 1°, 2°, 5°, or 10° steps from 90° or 180° as desired; a printer would automatically list the results. For those with computers, a program could be derived to plot the diagram as calculations progress.

Examine **fig. 5**. It has three lobes and two nulls; the one at 90° is not a full null. Our lobes as shown pictorially there, and tabularly in **table 3**, are at approximately *10°, 31°, and 60°. An important null* is at 20°. Why important? Twenty degrees vertical radiation from **fig. 2** with the ionosphere at 400 km, daytime F_2 layer height, is a good 1750 km hop.

From Cleveland, North Carolina, the distance to the heart of Germany is 7023 km, selected as being the center of a densely populated area. It so happens that 7023 km divided by 1750 km (the one-hop distance above) is exactly four hops. From **fig. 2**, the 10° signal gives a one-hop distance of 2650 km. Divide that number into 7023 and you will see it goes 2.7 hops. You can't have 2.7 hops, so you have to have 3 hops. Three times 2650 km is 7950 km. Therefore, the 10° vertically radiated signal lands almost 1000 km beyond the heart of Germany. However, if we had an antenna giving a 20° vertically radiating signal, it would be stronger than the 10° signal in that area when the ionosphere is at 400 km in height.

Referring back to **fig. 3**, you can see that a 20° vertical radiation can be obtained by an antenna height of 50 feet (15 meters). Superimpose this vertical radiation pattern on the vertical polar radiation diagram, **fig. 5**, to get a pictorial representation of how the 20° null is filled in by the 50-foot (15-meter) antenna. All vertical angles from about 6° through 36° are in excess of 80 percent of maximum signal. It is doubtful if you would want to use the 20-meter band for distances which 36° would provide — distances less than 1000 km one-hop.

Carry the analysis further to the 15- and 10-meter bands with an antenna at 100 feet and one at 50 feet (30.5 and 15 meters); see **figs. 6** and **7**. On 15 meters, the lower antenna fills in the null at 15°, but leaves a null at the 28° vertical angle of radiation. That angle is good for about 1200 km; again a lower frequency would be better.

On 10 meters the same combination appears to be good from about 3° through 17° to give at least an 80 percent of maximum signal over that range. Again, vertical angles greater than 17° on 10 meters probably are not necessary except for sporadic E transmissions. The 100-foot (30.5-meter) antenna by itself would leave some undesirable holes in your vertical radiation pattern.

Those Amateurs with a computer can have a great time moving displays around to show the vertical pattern for a single antenna at different tower heights with a lower antenna to fill in the nulls.

exciting two antennas for greater gain

Of course, once you have two antennas at different heights, your next inclination is to say, "Why don't I excite both of them and get additional gain?". Good idea, but first you should know, "What is that going to give me in the way of vertical angle radiation?" A good question, and its solution is as simple as adding on a second term to the equation we've already been using.

$$F(\alpha) = N\,[sin(h_1 sin\alpha) + sin(h_2 sin\alpha)] \qquad \textbf{(5)}$$

See **fig. 8** for definitions of h_1, h_2, and α; h_1 and h_2 are in electrical degrees for the frequency being measured. N is a normalizing factor (makes *maximum* $= 1$) and may vary from one design to another. First run the equation from 90° to the lowest angle. You will see maximum lobe results greater than 1. To normalize the data, divide all results by the highest lobe results. That makes the highest results equal to 1, with a corresponding decrease in all other numbers. This is called "normalizing the data," and permits an easier comparison of different designs.

The calculator or computer solves the equation for given heights of h_1 and h_2 and varies the vertical angle α from 90° down to zero when programmed properly. Taking 5° steps works out well, but 1° steps may have to be taken at crucial points to determine the maximum point of a particular lobe.

Using the 50-foot and 100-foot (15- and 30.5-meter) high antennas at 14.2 MHz fed in phase and solving the $F(\alpha)$ equation produced the plot shown in **fig. 9**. The plots of **fig. 5** are superimposed on **fig. 9** to show the comparison pattern of each single antenna and together. The curve has been normalized (*maximum point* $= 1$) to compare its vertical angle with respect to the 50-foot and 100-foot (15- and 30.5-meter) curves. It may be seen that the maximum lobe for the combination is at 12°, with three attenuated ones at 38°, 53°, and 90°. A gain of 3 dB is realized in the horizontal plane with the combined antennas.

You may be interested in determining for yourself

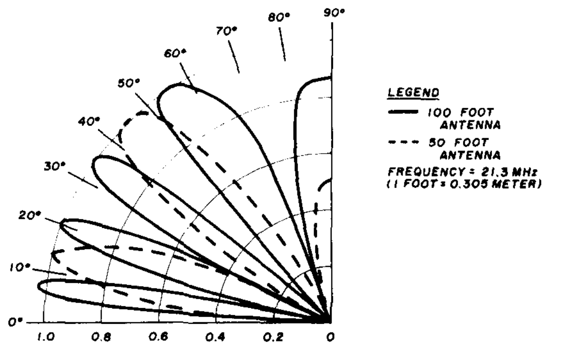

fig. 6. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled in by the lower antenna (frequency is 21.3 MHz).

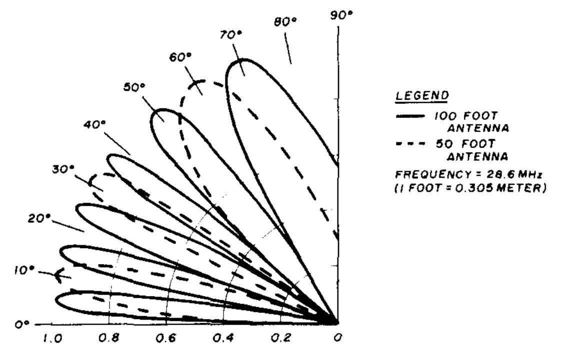

fig. 7. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled in by the lower antenna (frequency is 28.6 MHz).

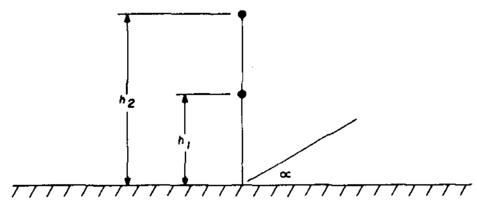

fig. 8. Definition of heights and vertical angle of radiation for two antennas excited in phase.

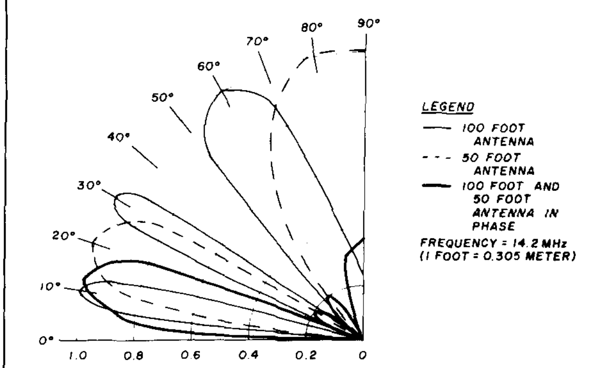

fig. 9. Comparison of the antennas of fig. 5 with the two antennas fed in phase to give an increase in gain in the horizontal plane. The pattern for the in-phase antennas has been normalized as explained in the text for comparison purposes.

what the pattern of half-wave spacing as well as 0.625-wavelength spacing would provide in the way of vertical radiation angles with height. The 0.625-wavelength spacing is the optimum spacing for maximum horizontal gain.

When striving for minimum vertical radiation angle, consider the following. **Fig. 2** shows that if the ionosphere were to attain a height of 500 km, the maximum one-hop distance would be 4850 km at 0° vertical angle of radiation. To attain a 0.1° angle of fire would require a horizontal antenna on 28.5 MHz to be at 4,944 feet (1508 meters) high. On 14.2 MHz, a 1° angle of fire would require an antenna at 992 feet (303 meters). So, do not expect to have horizontal antennas with a maximum lobe at 0°.

four-antenna array

As a final exercise for a 100-foot (30.5-meter) high tower, an array of four antennas spaced one-half wavelength apart for 15-meter operation was calculated. This is for the contester who wants to put a fixed array on the side of the tower for Japan, for example. The calculation is done using the same $F(\alpha)$ formula, but having four terms:

$$F(\alpha) = N\,[sin(h_1 sin\alpha) + sin(h_2 sin\alpha) + sin(h_3 sin\alpha) + sin(h_4 sin\alpha)] \qquad \textbf{(6)}$$

Fig. 10 shows the vertical signal to be expected. What a beautiful lobe with negligible high angle lobes, thus minimizing interference from short-haul stations. The vertical angle of about 8° produces about a 4-hop trip from North Carolina to Japan. If your 3-element Yagis were used, the horizontal gain would be 14 dB over a dipole. Sure beats a 12-element Yagi on a long boom for simplicity, and remember all the high-angle lobes you have to put up with using the single beam (refer to **fig. 6**).

conclusions

This article has attempted to point out the importance of designing an antenna system to put your *signal where you want* it to go. The variables under your control are the distance to your desired station and the height of your antenna. The variable not under your control is the height of the ionosphere. However, by judicious placement of secondary antennas in the vertical plane, you can effectively use changes in the height of the ionosphere and keep your maximum signal at a given receiver location.

Also, by knowing the vertical angle of radiation of your antenna you can determine proper height for short-haul contest work such as Sweepstakes, as well as long-haul DX contest or general DX work.

Although perhaps an over-simplification of the antenna problem, study of the multi-lobes of high antennas will show how "thin" the lobes are. Thus, changes in the ionosphere height will move the "footprint" of the transmitted signal into and out of your desired reception area more quickly than "fatter" lobes. Also, the multiplicity of lobes from the high antenna may result in multiple path fading problems, as explained earlier. Lower antennas and phased arrays have fatter lobes, hence a broader footprint, and will maintain their signal strength into their directed area for longer periods of time.

Ask yourself before investing in costly towers and antenna systems, "What are my antenna objectives?" Putting the signal into the area *you* want it to go still seems more important than putting the strongest signal wherever *it* wants to go. A study of your antenna objectives is not to be taken lightly!

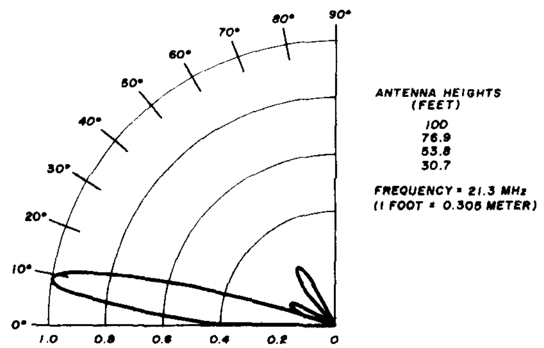

fig. 10. Results of feeding four horizontally polarized antennas in phase when stacked vertically to show elimination of extraneous major lobes (see fig. 6 for comparison). If three-element beams are used at each level, a 14-dB gain is realized in the horizontal plane.

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appendix

derivation of propagation-distance formula

Fig. A-1 shows a transmitting point at **A**, a reflection from the ionosphere at point **B**, and a one-hop return to earth at point **D**. The virtual height of the ionosphere is h_i, and the average radius of the earth, R_e, is a constant of 6,367.45 km. The intersection of the radius line from the center of the earth to its surface forms a right angle at point **A**. The vertical angle of radiation, α, is an angle that is added to 90° when determining angle CAB. The distance, **AD**, along any great circle on the surface of the earth is given by:

$D = R_e\theta$ when θ expressed in radians, or:

$$D = \frac{R_e}{57.296}\,\theta, \text{ when } \theta \text{ is expressed in degrees.}$$

The problem is to find a relationship of θ with respect to α and h_i and involves the triangle $CABC$. Two sides of that triangle are known: $BC = R_e + h_i$, $CA = R_e$. *Angle CAB* is known: $angle\ CAB = 90° + \alpha = angle\ A$.

Knowing two sides and one angle, the other side and angles may be determined from the law of sines.

solution of problem by law of sines

The law of sines says, given A, a, and b (see fig. **A-1**):

$$Angle\ C = 180° - Angle\ A - Angle\ B$$

$$= Angle\ BCA = \frac{\theta}{2}$$

Also, $\frac{b}{\sin B} = \frac{a}{\sin A}$, thus $B = \sin^{-1}\left(\frac{b \sin A}{a}\right)$

and $C = 180° - (90° + \alpha) - \sin^{-1}\left(\frac{b \sin A}{a}\right)$

Replacing the above with our own symbols:

$$\frac{\theta}{2} = 180° - (90° + \alpha) - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$$

$$\frac{\theta}{2} = 90° - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right] - \alpha$$

But $\sin(90° + \alpha) = \cos\alpha$

and $90° - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$

$$= \cos^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$$

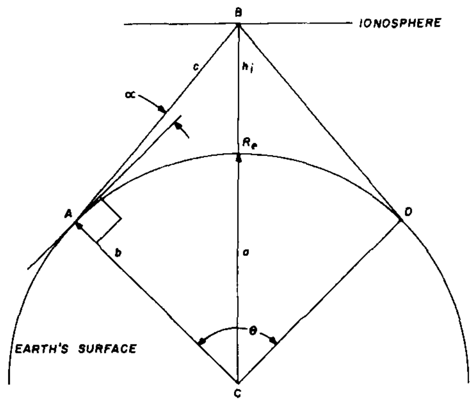


fig. A-1. Geometry for derivation of propagation-distance formula. Signal leaves the earth's surface at an angle, α is reflected from the ionosphere at point *B*, and returns to earth at point *D*.

Therefore, $\theta = 2\cos^{-1}\left[\frac{R_e \cos\alpha}{R_e + h_i}\right] - \alpha$

Knowing θ, we can now solve for D, and cleaning up the $\cos^{-1}$ term, we get:

$$D = \frac{2R_e}{57.296}\left[\cos^{-1}\left(\frac{\cos\alpha}{1 + \frac{h_i}{R_e}}\right) - \alpha\right]$$

but $R_e = 6{,}367.45\ km$

Therefore:

$$D = 222.265\left[\cos^{-1}\left(\frac{\cos\alpha}{1 + .000157h_i}\right) - \alpha\right] \text{ kilometers}$$

height-in-feet equation

We start with the given equation:

$$F(\alpha) = \sin(h \sin\alpha)$$

We wish to change h, which is in electrical degrees to h_{ft}, which is the height of our antenna in feet above the earth's surface.

We know that $1\lambda = 360°$. Therefore the fractional part of a wavelength (any antenna height) is the ratio of actual antenna height in feet to λ in feet times 360°.

$h = 360° \frac{h_{ft}}{\lambda_{ft}}$ *degrees, but* $\lambda = \frac{984}{f_{MHz}}$ *feet*

so $h = \frac{360}{984} f_{MHz} h_{ft} = 0.366 f_{MHz} h_{ft}$ *in feet*

We can say:

$$F(\alpha) = \sin\left[(0.366 f_{MHz} h_{ft}) \sin\alpha\right]$$

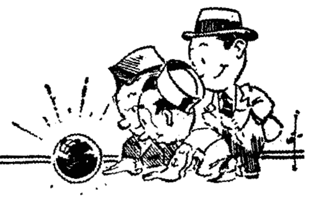
$$\sin^{-1} F(\alpha) = 0.366 f_{MHz} h_{ft} \sin\alpha$$

Therefore:

$$h_{ft} = \frac{\sin^{-1} F(\alpha)}{0.366 f_{MHz} \sin\alpha}$$

ham radio

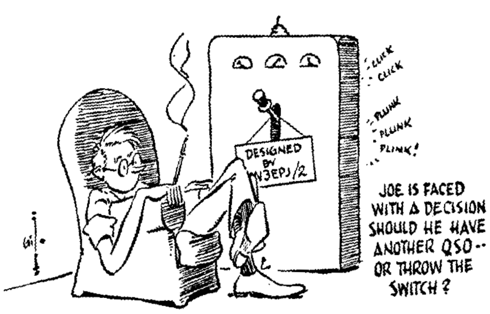
THE CRYSTAL BALL



ON OR OFF?

From the articles printed in the Crystal Ball it is evident that most of the brethren have their mental machinery running at prewar speeds. Don't they realize that we have entered upon a new era of rockets, A-bombs, robots, and fungicides? Why hack around with these pitiful pseudo-modern ideas for the new Ham Station? Here is a plan for a rig combining simplicity and ease of operation.

First let us examine the fundamental requirements of an ideal amateur station. The primary question confronting the average ham is: does he want his station *on* or does he want it *off*? Reference to the literature will confirm that an "on-off" switch is the most practical solution to this problem. Having established this component as a prerequisite, let us delve into the less-interesting sub-assemblies to be tied into the on-off switch. The best way to cover this is to describe the sequence of operations occurring when this switch is thrown from the "off" to the "on" positions.



Joe Blow strolls into his shack, turns on the aforementioned switch, lights a cigarette, and starts reading the latest copy of *Esquire*. Rotating beam antennas on all amateur bands start scanning the horizon, feeding in signals to appropriate receivers, which are scanning the bands in frequency, looking for a CQ. Let us suppose that the receiver system on band A finds a CQ first. The audio signal, having passed through the CQ-pass filters operates relays which deenergize the other receivers, switch off the scanning function of antenna A, and automatically point the beam at the originating transmitter by means of an appropriate servo system. Simultaneously, Joe's own transmitter is automatically tuned to the frequency of the incoming signal, and held in readiness to transmit. As soon as the received signal stops, the transmitter sends out a call automatically prepared on a magnetic wire recorder from the call sent by the other station and including Joe's call.

Whenever the other station breaks in, Joe's transmitter stands by and his receiving system comes into its own. Basically, the signal is fed into three channels, the Log Channel, the QSL Channel, and the Miscellaneous Channel. The Log Channel uses information contained in the signal relating to the signal strength and the time the QSO started, and prints it on the Log Sheet. The QSL Channel, in a similar manner, prints part of the QSL card. The Miscellaneous Channel accumulates the non-essential information passed out by the other station and feeds it into the waste basket. It also performs the very essential function of taking the signal report given, running it through a computer coordinating distance, number of previous QSO's, and blood pressure of Brother Joe in calculating a weighting formula to be applied to the otherwise accurate RST report to be given back to the distant station.

When the victim stands by, Joe's station automatically goes to the transmit position, sends out "Good Morning," "Good Evening," or "Good Afternoon," as determined by a suitably-connected clock, transmits the other fellow's RST report complete with fudge factor, gives the weather as measured by a barometer and thermometer on the roof, states the QTH (not a variable, making this part simpler), adds 73 and signs.

After the other station signs, the Log and QSL machines finish printing their respective cards. When this is complete and the QSL card has been automatically shot out to the nearest mail box, the second-hand air raid siren is energized to distract OM Blow from his *Esquire*. He is then faced with a decision. Should he let things take their course and have another QSO, or should he throw the switch to "off" and delve further into the printed pulchritude?

Carl C. Stotz, W3EPJ/2

Thanks to the ARRL for permission to reprint this column by Carl C. Stotz, W3EPJ/2 from the February, 1946, issue of QST.

ham radio TECHNIQUES

Bill Orr W6SAI

It is difficult to prophesy, especially with respect to the future. — Bob Booth, W3PS (Silent Key).

What will Amateur Radio be like in 2015? Will there be Amateur Radio in thirty-three years from now? Interesting questions, to be sure.

Reprinted from *QST* is a tongue-in-cheek prediction of Amateur Radio's future as seen from 1946. Is our vision of the future as clear as this one, written before the days of transistors, ICs, and computers?

Looking into the cloudy crystal ball, I see Amateur Radio flourishing in 2015 but in a far different form than the hobby of today.

- In 2015, all the computers, communications equipment, and data storage systems you see today will be obsolete museum pieces.
- By 2015, great advances in fiber-optic transmission will make cable communications and most radio communications over fixed, short distances obsolete.
- In 2015, long-distance communications will be exclusively by complex, wideband, high-power satellites and land-based repeaters.
- Radio transmission via the ionosphere, an unreliable medium at best, will be obsolete. VHF satellite repeaters and fiber-optic cables will replace them. *Radio, television, and fm broadcast stations as we know them today will not be in use in 2015; they will not be needed.*
- Home computers, tied into large computer networks around the world, will be commonplace. Information and entertainment will be available on a three-dimensional color screen in most homes.
- It will be possible to call up any of thousands of information channels at will — including direct communications with other computer terminals — worldwide.

why, then, Amateur Radio?

As a consequence of the information explosion and instant communications available in 2015, radio transmission in the medium- and high-frequency spectrum will be obsolete, except for some military purposes (over-the-horizon radar, the Woodpecker, for example), scientific studies, and Amateur Radio communications. All else will be transmitted by other, more reliable, means.

Radio Amateurs will not be restricted to bands in 2015. They will roam freely the entire high-frequency spectrum. And more. Amateurs will work alongside the few users of the radio spectrum over a frequency range of 500 kHz to perhaps 75 MHz. This is how it will be done.

the ham station of 2015

The Amateur station of the future will consist of a broadband transmitter, receiver, and antenna, computer controlled and capable of frequency-agile transmission at any point in the radio spectrum. Let's suppose Our Hero has one of these marvelous devices and wishes to make contact with another Amateur station.

The computer terminal is energized and a propagation display appears on the screen, derived directly from the International Weather Service through the optic-fiber communications line running into the home. Looking at Europe on the map, Our Hero decides it would be nice to have a chat with a German or French Amateur. He keys his instructions into the computer. Instantly his transmitter is armed with the proper data. It transmits a coded signal (similar to the CQ of olden days) that jumps about in frequency in a sequence selected by the computer that continually sweeps to interrogate the Maximum Usable Frequency (MUF) over the chosen path. Frequency agility is rapid, the signal remaining on any one spot for less than a second. To a casual observer, looking over the range of frequency spotting, *no signal is apparent.* To another observer, however, who has received the coded transmission and keys his equipment up in response to this code, an interference-free signal is received that contains the data needed to transmit a reply in the same coded sequence as that received.

Our Hero, then, has keyed in a frequency agility code, as well as codes that select the region of the earth (or country) to be scanned by his receiving computer. All this information appears on the video screen of his equipment.

The signal is ignored by all stations except those whose computers are programmed to search for the particular code Our Hero is using. Once a code match is established, the second ("reply") station alerts the first ("search") station that it is in lock. The search station may jump about in frequency to dodge interference, but its continually transmitted coding signal forces the reply station to follow it to the exact Hertz!

the QSO

Now that the two stations are completely in lock, the contact can run until the Maximum Usable Frequency falls below the critical cutoff frequency at which signals are lost on the particular path. Continuously listening to each other, the computers instantly shift frequency at will, seeking a clear channel for QRM-free communications.

Our Hero can now choose his mode of communications. Voice? Slow-scan digitized television? Practice CW? Or radio-teletype? Perhaps transmit some music? Why not? He can copy by ear, watch it on a video display, or record it on a form of tape for playback. Or he can do all of these at once.

While the QSO is in progress, giant Woodpecker transmitters used for ionospheric-reflected information gathering roam about the high-frequency spectrum. They, too, by international agreement are frequency-agile, perhaps transmitting only one pulse on a given frequency before moving on, continuously sensing the transmitting frequency for an existing signal before transmitting their powerful pulse.

Intermixed with the Woodpeckers are other forms of pulsed transmissions for military and scientific purposes. And dodging about in this signal mix are the Amateur signals. All services interrogate frequency after frequency until an open spot is found — then *zip*! the pulsed information is sent and retrieved and the transmitter moves on once again.

Listening to this frequency-agile, frequency-hopping, computer controlled mode of transmission on an ordinary receiver would reward the listener with only a random hum, or loud background noise. No intelligence would be apparent. But a locked "reply" station would instantly sift through the myriad signal bits and accept only those bits that its coded memory recognizes.

Armed with propagation information and a "callbook" of the transmission identification codes used by other Amateurs, Our Hero can quickly program his station to search for a single unique signal, or one group of signals among a family of signals, or any random signal the computer may process in a frequency search. Sometimes it might be fun to speak at random to any station caught during the computer search. And other times a certain station or region may be pinpointed for specific QSOs.

At any given time, tens or hundreds of Amateur stations would be scanning the high-frequency spectrum, either in search or reply mode. If Our Hero desires, each station scanned would pop up on the video screen, showing its individual coded signal (the equivalent of the call letters of half a century earlier). Our Hero can either pick out a contact as the codes pass across the screen or he can instruct his computerized receiver to pick the contact for him. Or he can project himself into the ether with his own coded signal, and wait until another Amateur station locks onto his coded series of pulses. Automatic or manual coded search is available at the touch of a button.

the station library

Once contact is established instant break-in is available, regardless of the communication mode chosen. Bandwidth can be tailored to fit the job at hand. If voice is chosen, the voice is converted into digital signals and reconverted back into speech at the receiving station. Each station will have a memory library tape of thousands of words and the computer will automatically translate one language to another provided the correct coded language information is sent along with the voice. While the Amateur's computerized vocabulary may be limited to perhaps 5,000 words or less, and his sentences may be somewhat constricted by the limited vocabulary of his equipment, a plain language QSO is possible, with each Amateur speaking his own native tongue. The computers will do the rest.

If it is desired, a digital printer will reproduce the QSL card, or photograph of the station, for instant printout at the other end. Or a video camera may be cut in for a slow scan picture of station and operator.

At the same time, Our Hero can be in contact with a local VHF repeater (or translator), which can bring in other interested parties to the QSO. These other Amateurs may be on various VHF bands, with simplified equipment that can transmit a signal capable of being translated to a high-frequency, computer-controlled station capable of worldwide communications. Perhaps the high-frequency station is a remote site, located on a commanding hilltop QTH and operated by club members who access the equipment with a private code. Thus the apartment-bound Amateur can achieve worldwide communications through a mini-watt control console that fits on a corner of his desk, or atop his 500-channel, three-dimensional color television receiver and stereo system.

Amateur licensing in 2015

Amateur Radio, like other forms of communications in 2015, is under the control of the Department of Communications, which replaced the antiquated Federal Communications Commission in 1986. The General class license costs ten "new" dollars, the new dollar being equal to one hundred old dollars (which were withdrawn from circulation in 1996 when their real value had depreciated to almost nothing).

The license, good for a lifetime, authorizes the Amateur operator to run up to 5 kW steady state or 50 kW peak power at a repetition rate of less than 10 microseconds. All operating frequencies between 500 kHz and 100 MHz are authorized. Mode of transmission is not specified. The license exam requires a knowledge of the international communications laws (the licensee must pass a simple exam, somewhat akin to the written portion of the driver's license test). There is no technical requirement, as Amateur equipment is too complex to work on or modify, and all operation and maintenance instructions are provided in a video tape supplied with the equipment and are further encoded in the computer. Since the Morse code is an outmoded form of communications, employed only by eccentrics, no code test is required.

As of 2015, there are over 40 million General class Amateur licensees in the United States, with an equal number scattered over the globe. Even so, with modern communications techniques, interference between Amateurs is at a minimum.

the VHF Amateur license

The highest grade Amateur license in 2015 is the VHF license, which permits operation above 100 MHz and includes satellite operation. A complex technical examination is required for this license. Only 550,000 such licenses exist in the United States.

The VHF Amateur has access to over one hundred high power, repeater style, synchronous satellites, plus the ten active repeaters on the surface of the moon and the three repeaters on Mars. With this galaxy of repeaters at his command, the VHF Amateur can talk to any spot on earth with a simple, ten-thousand channel hand-held VHF transceiver. In addition, he can talk with the hams stationed at the Moon Base (Luna One) and, at times, the hams on the first expedition to the moons of Jupiter and Saturn. He is also licensed for point-to-point earth VHF communications using various exotic modes of propagation.

the genesis of the 2015 ham station

For most of the twentieth century, high frequency communications were linked to limitations in frequency generation. At first, crystal control was used on discrete channels. Later the variable-frequency oscillator provided some limited flexibility over narrow bands. Thus, because of the rigid frequency-generation scheme, a complete legal and technical system was built up to control spectrum use. This led to the adoption of narrowband antenna systems for the frequencies assigned.

In the late fifties and early sixties, frequency synthesis became a practical reality, making possible high-frequency transmitting/receiving equipment capable of easily and rapidly tuning to any spot in the high-frequency spectrum. This revolutionary technique was inhibited by a regulatory process based upon decades of control built around an outmoded channelized, or "band assignment" concept. With the elimination of the Federal Communications Commission and the establishment of a new regulatory body that had expertise in "adaptive high frequency use," a new world of communications was opened for Radio Amateurs.

The new communications technique obviated frequency bands, heretofore thought sacrosanct. The new philosophy was to use low power equipment to sweep through the entire high-frequency range and to measure and log all propagation characteristics and interference, without indicating what frequency, or frequencies, would ultimately be used for communicating. Communications with a coded station could be established on any part of the high-frequency spectrum that would support a reliable radio path. Multiple transmission on two or more frequencies at one time, or sequential transmissions on multiple frequencies, was the powerful tool used to achieve reliable communications. Rapid frequency-hopping transmissions, moreover, eliminated the need for Service Assignments, so jealously guarded in the closing days of the late nineties. The old administrative limitations on spectrum occupancy were swept out with a convulsive, international conference, and new regulations were set up to reflect the modern technological revolution.

And thus Amateur Radio grew and prospered in the early years of the twenty-first century!

ham radio

HAM CALENDAR

May

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY

W1AW Schedule

October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule:

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M., TTh: 9 A.M.; TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M., MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M., TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M., TTh: 6 A.M., TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M., MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M., MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

1 (Saturday)

ARRL INTERNATIONAL EME COMPETITION – 1-2.

QUANNAPOWITT RADIO ASSOCIATION HAMFEST – South Hall Fire Station, corner of Salem and Summer Streets, Lynnfield. Contact KA1MI – 1.

SOUTHERN TIER ARC 23RD ANNUAL HAMFEST – Oswego Treadway, Oswego, NY. Contact Craig England, KF2X – 1.

YAKIMA ARC ANNUAL HAMFEST – Ahtanum Youth Activities Park, Yakima, WA. Contact Dave Pankey, N7BRB – 1-2.

BRISTOL, JOHNSON CITY & KINGSPORT ARC 2ND TRI-CITIES HAMFEST – Appalachian Fairgrounds, Gray, TN. Contact Tri-Cities Hamfest, POB 3682 CRS, Johnson City, TN 37601 – 1-2.

COUNTY HUNTERS SSB CONTEST – 1-2.

2 (Sunday)

FIFTH ANNUAL P.V.R.A. FLEA MARKET – George Penny H.S., East Hartford, Exit 91 off I-86. Contact K1NFE – 2.

CENTRALIA WIRELESS ASSOCIATION'S ANNUAL HAMFEST – Kaskaskia College Gym, 3 miles NW of Centralia. Contact Bud King, WB9QEG – 2.

AMATEUR RADIO FLEA MARKET – sponsored by the New England Amateur TV Group, Freeport Hall, Dorchester. Pre-register by April 25th to NEAT, POB 406, Boston, MA 02102 – 2.

TRI-COUNTY RADIO ASSOCIATION'S HAMFEST/FLEA MARKET – Passaic Township Youth Center, Valley Rd., Stirling, NJ. Contact Herb Klawunn, W2CHA, 201-647-3461 – 2.

LYNCHBURG ARC ANNUAL SWAPFEST – Brookville H.S., Route 460 west of Lynchburg, VA. Details via: POB 4242, Lynchburg, VA 24501 – 2.

3 (Monday)

GEORGIA QSO PARTY – 1-3.

WEST COAST BULLETIN – 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM – 3.

4 (Tuesday)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

5

6

7 (Friday)

HAMPDEN COUNTY RADIO ASSOCIATION'S ANNUAL FLEA MARKET – Feeding Hills Congregational Church, Routes 57 & 187, Feeding Hills, MA. Contact Larry Langevin, K1GXU – 7.

INDIAN RIVER ARC – "Sun-Day" operating on W4NLX/4 on 1300-1400 GMT, 40 meters, 7250 to 7275 kHz SSB, 1400-2000 GMT, 15 meters, 21350 to 21375 kHz SSB. For more information contact Florida Solar Energy Center, "Sun-Day," 300 State Route 401, Cape Canaveral, FL 32920 – 7-8.

8 (Saturday)

USSR "CQ M" CONTEST – 8-9.

ARROWHEAD RADIO AMATEUR CLUB'S ANNUAL SWAPFEST – At First United Methodist Church, 230 East Skyline Pkwy., Duluth, MN. Contact Jerry Frederick, NØBNG – 8.

OZAUKEE RADIO CLUB'S 4TH ANNUAL SWAPFEST – Circle B Rec Center, Highway 60, Cedarburg, WI. Contact Ozaukee Radio Club, POB 13, Port Washington, WI 53074 – 8.

GREATER FAIRFIELD ARA SPECIAL DOGWOOD FESTIVAL QSO PARTY – Members of the club (WB1COO) will be on six Amateur Bands to explain the festival. 1300-2200 UTC or 9 AM to 6 PM EDST. SSB Frequencies: 3975, 7235, 14330, 21420 and 28710 MHz. FM 146.55 simplex. Contact KA1JT with SASE for QSL – 8.

PUTNAM EMERGENCY AMATEUR RADIO LEAGUE'S FIRST ANNUAL HAMFEST – JFK Elementary School, Foggintown Rd., Brewster, NY. Contact Frank Konecnik, WB2PTP – 8.

9

10 (Monday)

W1AW QUALIFYING RUN – 10.

11 (Tuesday)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

12 (Wednesday)

HOLLAND ARC will operate K8DA with other participating stations during Netherlands American Bicentennial during Tulip Time. Operations on all phone bands and some CQ. QSL to HARC, POB 92, Zeeland, MI 49464 – 12-16.

13

14 (Friday)

EIGHTH ANNUAL EASTERN VHF/UHF CONFERENCE – Sheraton Inn and Conference Center, Boxboro, MA. Contact Rick Commo, K1LOG – 14-16.

15 (Saturday)

MICHIGAN QSO PARTY – 15-17.

FLORIDA QSO PARTY – 15-16.

ROCKINGHAM COUNTY ARC will operate from Cape Hatteras Lighthouse. Operating frequencies: 30 Kc up from bottom of general portion of each band, phone and CW – 15-16.

NORTHWEST ARKANSAS ARC 2ND ANNUAL HAMFEST/SWAP-MEET – Community Bldg., Rogers on US Hwy 71. Contact Mary Webb, KA5HEV – 15.

DURHAM FM ASSOCIATION'S ANNUAL DURHAMFEST – South Square Mall, U.S. 15-501 south. Contact Durhamfest, Box 777, Hillsborough, NC 27278 – 15.

16 (Sunday)

YAKIMA ARC, W7AQ – Special event station for anniversary of Mt. Saint Helens eruption. 1800 May 16th to 0200 May 17th UTC. Frequencies will be 25 kHz up from bottom of General phone edge; CW up 25 kHz from Novice band edge and at 14.050, all ± QRM and band conditions. QSL available by SASE to W7AQ – 16-17.

INDIAN FOOTHILLS ARC 7TH ANNUAL HAMFEST – Saline County Fairgrounds, Marshall, MO. Contact Jim Little, KBØDA – 16.

WARMINSTER ARC ANNUAL HAMFEST – Middletown Grange Fairgrounds, Wrightstewn, PA. Contact Bill Scott, KA3CHB after 6 PM (215) 249-0568 – 16.

EASTON ARS 8TH ANNUAL HAMFEST – Easton Sr. H.S., Easton, MD. Contact Van Herridge, WB3HGO – 16.

WABASH COUNTY ARC'S 13TH ANNUAL HAMFEST – Wabash County Fairgrounds, Wabash, IN. Contact Dave Spanger, N9ADO.

TRI-STATE ARS ANNUAL HAMFEST – Vanderburgh County 4H Center, Evansville, IN. Contact Hal Wilson, WB9FNN – 16.

17 (Monday)

WEST COAST BULLETIN – 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM – 17.

18 (Tuesday)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

19

20

21 (Friday)

WIESBADEN ARC 7TH ANNUAL DXPEDITION TO LIECHTENSTEIN – Callsign DA1WA/HBO. CW, Phone and RTTY, all frequencies, 10 to 160 meters. CW operations for American stations will be attempted at 3.725 and 21.120 MHz between 1900 and 2100 EST. Send SASE to S. Hutchins, POB 4573, APO New York 09109 for QSL – 21-30.

FRESNO ARC 40TH ANNUAL HAMFEST – Hacienda Inn, Clinton & Hwy. 99, Fresno, CA. Contact Fresno ARC, POB 783, Fresno, CA 93712 – 21-23.

22 (Saturday)

SOUTH SHORE REPEATER ASSOCIATION'S ANNUAL HAM RADIO/ELECTRONIC/COMPUTER FLEA MARKET – South Weymouth H.S. Cafeteria. Contact SSRA, David Newman, POB 447, Abington, MA 02351 – 22.

PORTLAND AMATEUR WIRELESS ASSOCIATION & SOUTHERN MAINE UNIVERSITY RADIO CLUB – Annual Flea Market, Gorham, Maine campus. Contact John Taylor, N1SD – 22.

ARRL DELTA DIVISION CONVENTION & 16TH ANNUAL KNOXVILLE HAMFEST – Bearden H.S., 8352 Kingston Pike, Knoxville, TN. Contact Raymond Adams, N4BAQ – 22-23.

CLARK COUNTY ARC 2ND ANNUAL MT. SAINT HELENS QSO PARTY – Frequencies: SSB: 3805, 7230, 14280, 21360, 28505. CW: 3705, 7105, 21105, 28105. VHF: Various Vancouver and Portland area repeaters. For QSL send to Award Manager, W7AIA, POB 1424, Vancouver, WA 98778 – 22-23.

ANDERSON, HARTWELL & TOCCOA ARC ANNUAL HAMFEST – Lake Hartwell Group Camp, Hwy. 29, Lake Hartwell, GA. Contact Ray Pettit, WB4ZLG – 22-23.

SMITHS FALLS ARC – Special events station, CZ3SFR on all HF bands and 2 meters VHF. Send SASE to POB 215, Smiths Falls, ON, Canada K7A 4T1 for QSL – **May 22 - June 7.**

ROCKY MOUNTAIN QSO PARTY – 22-23.

23 (Sunday)

PITTSBURG REPEATER ORGANIZATION'S 8TH ANNUAL HAMFEST & PICNIC – Lincoln Center, Pittsburg, KS. Contact KC0ES, 505 Karen Dr., Carl Jct., MO 64834 – 23.

OLD NATCHEZ ARC HAMFEST – Natchez Convention Center. Contact S.W. Gates, N5AXV – 23.

FALL RIVER ARC FLEA MARKET – American Legion Hall, Freetown, MA. Contact Ann Carro, KA1DNB – 23.

CHIPPEWA ARC 20TH ANNUAL HAMFEST – Garnett North Lake, Garnett, KS. Contact Reid Richardson, 518 West 7th, Garnett, KS 66032 – 23.

ROCKY MOUNTAIN VHF SOCIETY'S ANNUAL SPRING HAMFEST – Boulder National Guard Armory, 4750 North Broadway. Contact Richard Ferguson, KAØDXM – 23.

N.K.A.R.C.'S ANNUAL HAM-A-RAMA – Burlington Fairgrounds, off 2-75 Florence exit. Contact Jack R. Thompson, 637 Wolf Road, Covington, KY 41015 – 23.

ILLIANA REPEATER SYSTEM'S ANNUAL DANVILLE AREA HAMFEST – Georgetown Fairgrounds. Contact Wendell Lyons, KA9AYS.

3RD ANNUAL MAARC HAMFEST – Ball State University indoor track bldg., Muncie, IN. Contact Terry Evans, WD9HQH – 23.

OHIO RADIO CLUB & OTTAWA COUNTY ARC HAMFEST – Fremont, OH Fairgrounds. Contact John Dickey, W8CDR – 23.

LONG ISLAND MOBILE ARC HAMFAIR – Islip Speedway, Long Island, NY. Contact Sid Wolin, K2LJH or Hank Wener, WB2ALW.

28TH ANNUAL BREEZE SHOOTERS HAMFEST – White Swan Amusement Park, PA. Contact Joe Kyler, K3SJD – 23.

24

25 (Tuesday)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

26

27

28

29

30

31 (Monday)

BISHOP ARC will operate KA6AMT from the mule capitol of the world, Bishop, CA, in celebration of the Annual Mule Days. Frequencies: Phone 3905, 7240, 14295, 146.34/.94. For QSL send SASE to Bishop ARC, POB 1024, Bishop, CA 93514 – 31.

*See Coming Events

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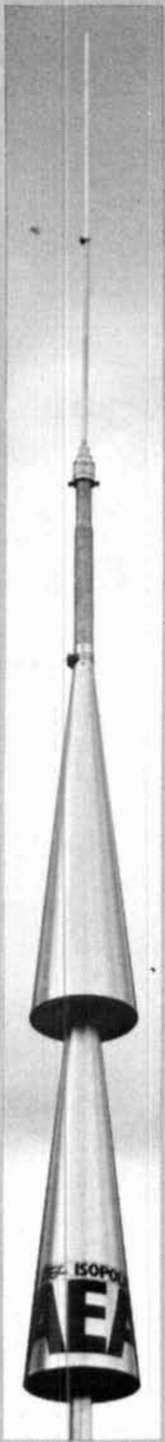

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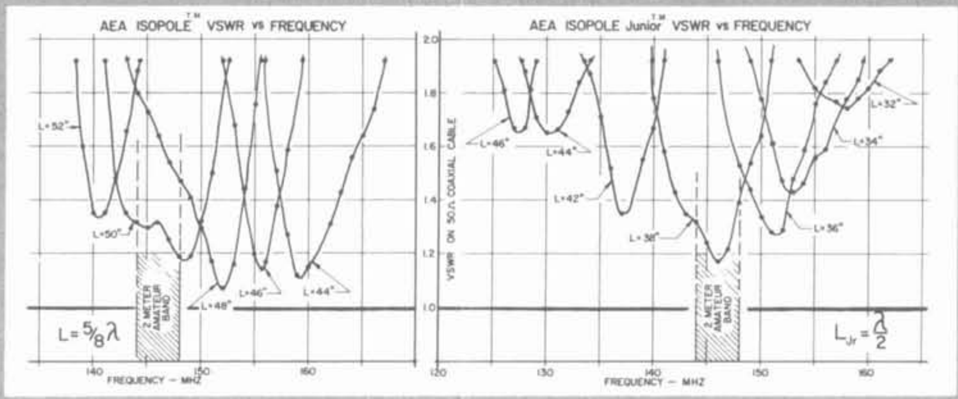
All IsoPole antennas yield the maximum gain attainable for their respective lengths and a zero degree angle of radiation. Exceptional decoupling results in simple tuning and a significant reduction in TVI potential. Cones offer greater efficiency over obsolete radials which radiate in the horizontal plane and present an unsightly bird's roost with an inevitable "fallout zone" below. The IsoPoles have the broadest frequency coverage of any comparable VHF base station antenna. This means no loss of power output from one end of the band to the other when used with SWR protected solid state transceivers.

ISOPOLE 440



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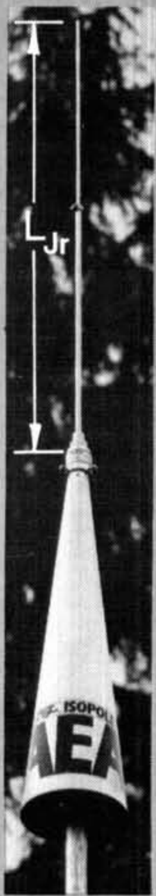

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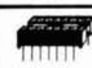

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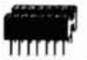
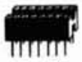


	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD



	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
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40 pin WW	2.29	2.09	1.89

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ASST. 3	5ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50pcs.	$1.95
ASST. 4	5ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50pcs.	$1.95
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ASST. 6	5ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50pcs.	$1.95
ASST. 7	5ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

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5/82

INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	24.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	12.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	13.95
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	6.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8038CCPD	Waveform Generator	4.95
8048CCPE	Monolithic Logarithmic Amp	21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.95
8212CPA	Volt Ref/Indicator	2.95

74C

Part	Price	Part	Price	Part	Price
74C00	.39	74C95	1.59	74C221	1.95
74C02	.39	74C107	1.89	74C240	2.25
74C04	.39	74C151	2.95	74C244	2.25
74C08	.39	74C154	3.95	74C373	2.49
74C10	.39	74C157	2.25	74C374	2.59
74C14	.75	74C160	1.69	74C901	.69
74C20	.39	74C161	1.69	74C903	.69
74C30	.39	74C162	1.49	74C911	10.95
74C42	1.29	74C163	1.69	74C912	10.95
74C48	1.95	74C164	1.59	74C915	1.69
74C73	.79	74C173	1.39	74C917	10.95
74C74	.79	74C174	1.39	74C922	5.49
74C85	1.95	74C175	1.19	74C923	5.75
74C86	.39	74C192	1.69	74C925	7.50
74C89	6.95	74C193	1.69	74C926	7.50
74C90	1.29	74C195	1.59	80C95	.79
74C93	1.29			80C97	.79

LINEAR

Part	Price	Part	Price	Part	Price
LH0002CN	6.85	LM340T-5	1.25	LM702H	.79
LM10CLH	4.50	LM340T-12	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-15	1.25	LM709N	.29
LH0070-0H	4.95	LM341P-5	.75	LM710N	.79
TL071CP	.79	LM341P-12	.75	LM711N	.79
TL072CP	1.39	LM341P-15	.75	LM723N	.69
TL074CN	2.49	LM342P-5	.69	LM733N	1.00
LH0082CD	35.80	LM342P-12	.69	LM739N	1.19
TL082CP	1.19	LM342P-15	.69	LM741CN	.35
TL084CN	2.19	LM348N	1.25	MC1741SCG	3.00
LH0094CD	36.80	LM350K	5.75	LM747N	.79
LM300H	.99	LF351N	.60	LM748N	.59
LM301CN	.35	LF353N	1.00	LM1014N	2.75
LM302H	1.95	LF355N	1.10	LM1310N	1.95
LM304H	1.95	LF356N	1.10	LM1458CN	.59
LM305H	.99	LM358N	1.00	LM1488N	1.25
LM307CN	.45	LM359N	1.79	LM1489N	1.25
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LM309K	1.25	LM377N	2.95	LM1800N	2.95
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LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
LM320K-15	1.35	TL494CN	4.49	LM3900N	.69
LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.25
LM320T-12	1.25	NE510A	6.00	LM3909N	1.15
LM320T-15	1.25	NE529A	4.95	LM3914N	3.95
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LM334Z	1.30	NE550A	1.30	RC4194TK	6.95
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LM336Z	1.75	LM556N	.99	LM4500A	3.25
LM337T	1.95	NE564N	3.95	ICL8038B	4.95
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LM339N	.99	LM567V	1.25	75138N	1.95
LM340K-5	1.35	NE570N	4.95	75460N	.89
LM340K-12	1.35			75451CN	.39
LM340K-15	1.35			75492	.89

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/25V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

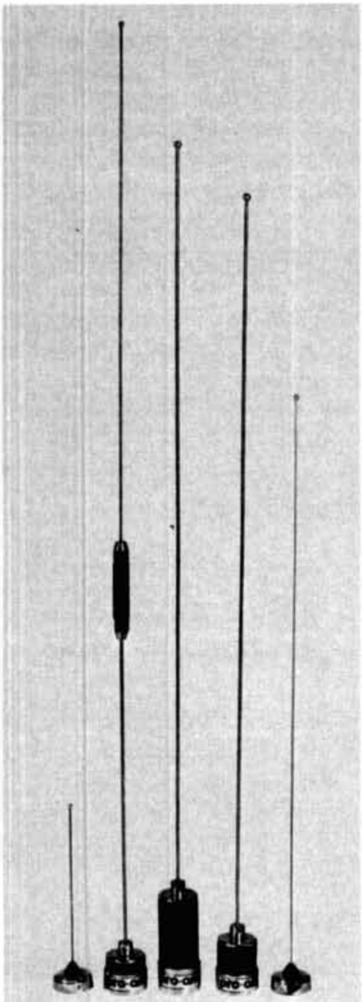
MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.16	.14	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.16	.12	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.23	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

NEW products

Valor's PRO-AM line

Valor Enterprises introduces a new line of PRO-AM (Professional-Amateur) antennas, mounts, and accessories. Valor's PRO-AM line is compatible and interchangeable with the Motorola TAD and TAE type mounts. This system is used extensively in commercial two-way and Amateur applications. Two basic mounts offer installation into a 3/4-inch or 3/8-inch hole; both utilize a 1-1/8 — 18 thread for mating parts. All components are inspected and tested to rigid commercial standards to insure performance in the most demanding environments. Quality materials include stainless steel whips and set screws, nickel-chrome brass parts, heavy gauge weather-proof coils, nickel-silver contacts, and O-ring seals.



PRO-AM antennas. From left, Models PAQ, PUB, PLB, and PAQ.

Four mounts are offered: Model PAS, the basic surface mount that installs in a 3/4-inch hole in roof, fender, or cowl. Includes 17-inches RG-58 with PL-259 connector; Model PAS38, the basic surface mount that installs in 3/8 inch hole in roof, fender, or cowl; Model PAT, a heavy-duty no-hole trunk mount. Black ABS cup, 17 inches RG-58 with PL-259 connector; Model PAM, a low-profile, chrome-plated magnet mount with 12 inches RG-58 with PL-259 connector.

PRO-AM antennas are divided into four types: Model PLB, a 1/4-wave base-loaded low-band antenna. Five models cover 27-54 MHz. 200-watt power-rated, with cutting chart; Model PAQ, 1/4-wave, unity-gain VHF-UHF whips. Twelve models cover 136-866 MHz. Passivated 302 s.s. whips factory tuned, ready to install. Nickel-chrome brass base, 150-watt power-rated; Model PHB, a 5/8-wave, 3 dB-gain VHF antenna. Two models cover 144-174 MHz and 220-225 MHz. 200-watt power-rated, with cutting chart; Model PUB, a collinear 5-dB-gain UHF antenna. Four models cover 440-512 MHz. 200-watt power-rated, with cutting chart.

For more information, contact Valor Enterprises, Inc., 185 West Hamilton Street, West Milton, Ohio 45338; telephone 513-698-4194 or 1-800-543-2197.

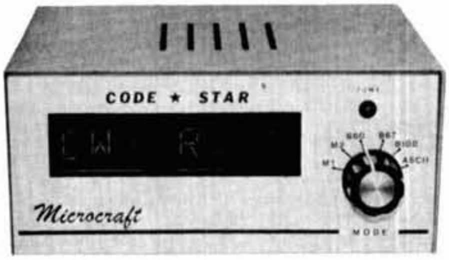
Code*Star

Microcraft announces its new all-mode code reader and code converter, Code*Star. Code*Star is designed for novices, SWLs, and veteran Amateurs. It should also be very useful to people learning or trying to improve their Morse code skills.

Code*Star's microcomputer monitors the incoming signal and converts it to characters on its large, easy-to-read LEDs. It decodes Morse code, Baudot (RTTY) and ASCII code.

Code*Star features two specially optimized Morse code ranges with auto-tracking of speed from 3 to 70 WPM. Special proprietary analog and digital filter methods are employed to substantially reduce errors. An automatic gain control circuit providing up to 16 dB gain is used to help maintain signals under fading conditions. A built-in code practice oscillator is handy for code practice and learning the code.

Code*Star operates on 12 Vdc which makes it ideal for field or mobile applications. An ac adapter is included if you wish to operate it from 120 Vac. As a special option you can use Code*Star to drive a serial or parallel ASCII printer, TV terminal or computer.



Code*Star is available as a complete kit or factory wired and tested. The kit, Model CS-K, sells for $169.95 plus $5.00 shipping and handling. The factory wired version, Model CSF, sells for $249.95 plus $5.00 shipping and handling. The optional ASCII output port kit, Model CS-IK, sells for $69.95 plus $2.50 shipping and handling.

For more information, contact Microcraft Corporation, P.O. Box 513, Thiensville, Wisconsin 53092; telephone 414-241-8144.

NEW products

35-watt, 2-meter amp

The Model 335A-K is an improved version of our reliable Model 335 amplifier kit. The Model 335A-K represents the latest in the state-of-the-art in 2-meter amplifier design. It incorporates new features which make it one of the most useful amplifiers available today.

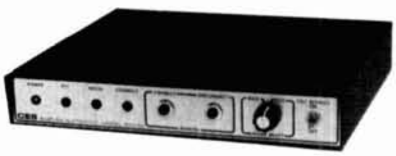
The Model 335A-K is a linear amplifier and can be used on fm, SSB, or CW. The Model 335A-K can be used with all available handhelds (TR2400, TR2500, IC-2AT, Yaesu, Santec, etc.) and low power SSB transmitters to give added range and versatility.

The Model 335A-K can be assembled easily in one evening using the step-by-step instruction manual. The quality parts and rugged construction used throughout the Model 335A-K make it a very reliable amplifier. When you construct the amplifier yourself, not only will you be saving money, but you will also experience the pleasure of constructing some of your own gear.

For more information, contact Communication Concepts, Inc., 2648 N. Aragon Ave., Dayton, Ohio 45420; telephone 513-296-1411.

CES 500SA autopatch

The new CES 500SA simplex autopatch is a high-quality unit that is surprisingly versatile and affordable ($350.00 suggested retail price). It provides positive radio operator control and eliminates telephone VOX circuits with a proprietary noise-gated sampling circuit.



Suggested applications for the Model 500SA include mobile/remote base to telephone line via simplex base; mobile to mobile via phone-interconnected base stations (for greatly extended range); and telephone line to mobile/remote base.

For more information on CES 500SA autopatch and other quality CES products, contact CES, Inc., Post Office Box 507, Winter Park, Florida, or telephone (305) 645-0474.

field-tuneable antenna

Centurion International has introduced a new field-tuneable replacement antenna for hand-held radios in the range of 66-88 MHz.

The new flexible antenna is available with any of the twenty-five different connector configurations in the standard Centurion line. This selection ensures high performance replacements for virtually any radio antenna in this band.

Centurion field-tuneable antennas are protected by a neoprene jacket with flexibility between −55°C and 100°C. The jacket is self-extinguishing when exposed to flame. Approximate length is 10 inches.

For more information, contact Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501-2846; telephone 402-467-4491.

NEW products

XZ-2 audio CW filter

Long known as a manufacturer of quality keys and baluns, Bencher now introduces the XZ-2 audio filter. As mentioned in D.A. Tong's article in the November, 1981, issue of *ham radio*, now that almost all receivers in use by hams feature good basic selectivity, it only makes sense to perform final bandwidth shaping in the receiver's audio section.

Use of the XZ-2 is simple and easy. The filter has four selectivity selections: SSB, 150 Hz, 115 Hz, and 90 Hz. The XZ-2 runs on 12-16 Vdc, which can be supplied by Bencher's 12-volt accessory power supply (#190-10). Audio can be taken from a number of convenient places; Bencher suggests that the phone patch outlet may be the most convenient. For our test, we connected the filter to the external speaker plug and put the filter in line with the speaker. This method provided convenient access to the headphone jack for test purposes. Actual testing took place over several days of casual operating and during CQ's WW CW contest.

When the power is connected, the unit remains on until power is removed. There is no way to completely remove the audio filter from the line, as may be done with several other makes of external filters. This isn't a major problem, however. It means that audio is still slightly amplified by the unit but it is bypassing the filtering stages. To our ear this was a bit of an annoyance, more due to the "newness" of the audio sound rather than a degradation of performance.

To use the filter, Bencher suggests that you tune the receiver with the filter set to SSB. This will allow you to hear a wide range of signals as you tune the CW band. When you hear a station you want, switch in as much selectivity as is required to eliminate adjacent-channel interference. When you are trying to copy an exceptionally weak signal in the presence of stronger signals, Bencher suggests that you increase the audio gain and decrease the rf gain as much as possible. Reducing the rf gain will limit the AVC control by the stronger signal. While trying to muck out a weak DX signal in the presence of a very strong stateside station, we found that Bencher's suggestions worked very well and we were able to effectively null out the interference created by the adjacent frequency station.

In comparison with the receiver's internal i-f filters and passband tuning, the XZ-2 shows up quite favorably. Used in conjunction with the receiver's built-in filtering, the XZ-2 is even better.

During the CQ WW contest, the XZ-2 was used both independently and with the receiver's filters. Of note is the fact that there are switches to be switched and dials to be turned to use the unit. In the heat of the contest this can hinder speed of operation. It's our operating preference to scan with the filter on wide bandwidth and then narrow down when a station is found. We do not do a lot of contest work, and so this is not much of a problem. But for a dyed-in-the-wool contester, it will be necessary to select, and remain with, one filter position. The filter performed very well during the contest and permitted us to work a number of stations we feel confident would have been missed without the external filter.

One final note. For those who own super-selective receivers, the XZ-2 can be a very valuable addition to the hamshack. As Dr. Tong says, audio filters are the next logical step for improving station performance. We are sure you will be pleased with Bencher's XZ-2 audio filter.

The Bencher XZ-2 filter sells for $69.95, plus $9.95 for 12-volt power supply. For further information, contact Bencher, Inc., 333 West Lake Street, Chicago, Illinois 60606.

the editors

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20 bis, Ave des Clarions
F-89000 Auxerre
France

Ham Radio Germany
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Holland
Postbus 413
NL-7800 Ar Emmen
Holland

Ham Radio Italy
G. Vulpetti
P.O. Box 37
I-22063 Cantu
Italy

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio UK
P.O. Box 63, Harrow
Middlesex HA3 6HS
England

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

More Details? CHECK—OFF Page 100

CADILLAC OF QSL CARDS, 3 to 4 colors, send $1 for samples (Refundable). Mac's Shack, P.O. Box 43175, Seven Points, TX 75143.

QSL ECONOMY: 1000 for $13. SASE for samples. W4TG, Box F, Gray, GA 31032.

HEATHKIT HW-101, very good condition with power supply, speaker, microphone, CW filter and manual. $375/offer, I ship. N9CFI, 12336 W. Holt, West Allis, Wis. 53227.

MOBILE OPERATORS: Anteck's Mobile Antennas cover 3.2 to 30 MHz inclusive, with no coil changing. 50 Ohms input. Two models, the MT-1 MANUAL, MT-1RT REMOTE-TUNED from the operators position. Uses two Hyd. Pumps and Motors. MT-1 $129.95, MT-1RT $240.00 *plus UPS postage. Check your local dealer or write for* Dealer List and Brochure. ANTECK, INC., Route One, Box 415, Hansen, ID 83334. 208-423-4100.

RTTY AND ASCII for your Atari Computer: Modem, personalized program and manual to get your Atari on ASCII & RTTY. $125. 16K and Atari 850 interface required. You must include your name, QTH and call sign. Write: Robert Holsti, K7ZJD/KH2, POB 4426, AAFB Br., Yigo, Guam 96912.

WANTED: Micor and Mstr II Base Stations 406-420 and 450-470 MHz. Also 2 and 6 GHz solid state microwave equipment. AK7B, 4 Ajax Place, Berkeley, CA 94708.

WANTED FOR PARTS: Royce 1-612 CB transceiver, phase lock loop box must be working. Emil Polashek, 117 E. Third St., Cresco, Iowa 52136.

AMP-LETTER: Devoted to designing, building, and operating Amateur Radio Amplifiers. Sample $2.00. AMP-LETTER, RR2 Box 39A, Thompsonville, IL 62890.

SPRING CLEANUP — Commercial tower, 150 feet, suitable for large Amateur arrays, broadcasting or TV, with guys and insulators, recently removed from service, pictures on request. Heath HW101 transceiver, PS23B, MFJ *Grandmaster memory keyer and 520 BX speech processor.* All guaranteed A1 working condition. Renwick, P.O. Box 50, Clavet, Sask., Canada, S0K 0Y0. (306) 373-1988.

TUBES, TUBES wanted for cash or trade. 304TL, 4CX1000A, 4PR60C, 7F7, 7N7, 53, 6L6M. Any high power or special purpose tubes of Eimac/Varian. DCO, 10 Schuyler Avenue, No. Arlington, NJ 07032. (800) 526-1270.

WANTED: Hammerlund HQ145. Call Arnie (212) 925-6048.

HAM RADIO FANATICS! You need the W5YI Report — Twice monthly award-winning insider newsletter. 24 issues — $18.00. Sample issue SASE (2 stamps). W5YI, Box #10101-H, Dallas, Texas 75207.

ATLAS 350XL, DD6XL, AUXVFO305 $850. Icom IC211 $450. SASE for list. K4TO, Dave Sublette, 1207 Monte Sano Blvd., Huntsville, AL 35801.

ATLAS DD6-C Digital Dial $120.00 plus $4.00 UPS. NEW, while they last. Mical Devices, P.O. Box 343, Vista, CA 92083.

BUY-SELL-TRADE. Send $1.00 for catalog. Give name, *address and call letters. Complete stock of major brands* new and reconditioned Amateur Radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. 913-381-5900.

CONNECTICUT'S Ham Store — Rogus Electronics, 250 Meriden-Waterbury Turnpike, (Rt. 66) Southington. (203) 621-2252.

RTTY FOR SALE: Several machines remaining. Model 15, Model 19, 28RO w/gearshift, p.s. for ROBOT 800, deluxe 34ASR, 28KSR, 28 keyboard typing reperf, 28TD's, 33KSR, 33ASR, 35KSR, *several demodulators, video RTTY.* Model 28 gearshifts, parts and supplies. Send SASE for complete list and prices. Lawrence R. Pfleger, K9WJB, 2600 S. 14th Street, St. Cloud, MN 56301. Phone (612) 255-9794.

ELF II with Giant Board, 8K memory, terminal, complete software package and manuals. $400. Steven Powell, 12607 Wellington Park, Houston, TX 77072 (713) 495-0488.

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box R802, Council Bluffs, Iowa 51502.

FOR SALE: TRS-80 model III, 16k computer and accessories. $900.00. Phone: 626-0402. Jim Bellini, 1005 Arland St., Rock Falls, IL 61071.

DON'T GET STRANDED! Battery Watchdog's alarm informs you of excess power drain. $19.95. J.F. Ratcliff, 3600 Meadow N., Renton, WA 98056. SASE brochure.

WANTED: Surplus 1-3 kW HF transmitter type FRT-15, Collins TDH or equivalent, or higher power up to 20kW SSB not necessary. P.J. Plishner, 2 Lake Ave. Ext., Danbury, CT 06810. WA1LDU.

RTTY JOURNAL-EXCLUSIVELY AMATEUR RADIOTELETYPE, one year subscription $7.00. Beginners RTTY Handbook $5.00, RTTY Index $1.50. P.O. Box RY, Cardiff, CA 92007.

HARDWARE/SOFTWARE subassembly provides Morse-ASCII conversion without any manual adjustments. Many extras. $169 bargain. Telecraft Laboratories, Box 1185, E. Dennis, Mass. 02641.

CUSTOM EMBROIDERED EMBLEMS — Your design, low minimum. Informational booklet. Emblems, Dept 65, Littleton, New Hampshire 03561. (603) 444-3423.

PACKET RADIO — Start a network with our hardware and free software using HDLC, ASCII. Smart terminal controller pcb $30, parts $112. 1200 baud radio modem pcb $15, tested $70. Newsletter $10. VADCG, 818 Rondeau St., Coquitlam, B.C, Canada V3J 5Z3.

OUR KEYERS turn difficult DX into logged contacts. SASE for information. Webco, Box 740211, Houston, Texas 77274.

SELL: 4-NB noise blanker from Drake R4C, $30 postpaid. HQ-180C and speaker $225. Much high-power gear. M.E. Coombs, 839 West M, Springfield, Oregon 97477.

WANTED: Pre-1950 TV sets and old TV Guides. Jeff Kadet, W3CRH, Box 90-HR, Rockville, MD 20850. (301) 654-1876.

SINCLAIR RADIO LABS MR-344B four cavity 450 MHz duplexers. Mint condition, $25. Alan Brown, K5MW, Route 4, Box 200-A, College Station, Texas 77840.

TRYING TO CONTACT present and retired employees of the E.I. DuPont de Nemours Company of Wilmington, Delaware. A DuPont Employees Callbook is being researched with publication expected in June 1982. Write to O.R. Averitt, Building 357, DuPont Experimental Station, Wilmington, Delaware 19898 for information.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-3, HT-19, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

ROHN TOWERS — Wholesale direct to users — all products available — write or call for price list. Also we are wholesale distributors for Antenna Specialists and Regency FM radios — Hill Radio, P.O. Box 1405 — 2503 GE Rd., Bloomington, IL 61701. (309) 663-2141.

YAESU OWNERS: Join your International Fox-Tango Club, now in its eleventh year. Calendar year dues still only $8 US, $9 Canada, $12 airmail elsewhere. Don't miss out, get 1982 top-rated FT Newsletters packed with modifications monthly, catalog of past modifications, free advertisements, technical consultation, FT net (Saturdays, 1700Z, 14.325 MHz), more. Go Fox-Tango! To join, send dues to FT Club, Box 15944, W. Palm Beach, FL 33406.

SALE NEW FRG-7 in factory sealed carton for $250 including shipping and original invoice dated Feb. 1982. Roy Merkel, W3HPP, 959 Georges Lane, Warminster, PA 18974. (215) 675-5864.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

FOR SALE: Yaesu FT101E with digital display YC601 — together with DenTron linear MLA 2500. Best offer — all guaranteed perfect condition — on air every morning 3990 KC. Tel 1-401-789-1817. W1CPI.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

HAM-AD-FEST™ — Next 6 issues, $2.00. WA4OSR, Box 973, Mobile, AL 36601.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

SAFETY BELTS. $35.00 and up. Free information. Avatar Co., (W9JVF) 1147 - (H) N. Emerson, Indianapolis, IN 46219.

CONTESTERS: Package of programs designed for the ARRL DX, CQWW, CQWPX and IARU Radio Sport Contests produces scored, duped log, dupe sheet, QSLs and many valuable operator statistics. TRS-80 Model 1, 48k, 1 or more discs, MX-80 printer required. $69.95 plus tax non-refundable. Sample printout with SASE. P. Chamalian, W1RM, P.O. Box 1188, Burlington, CT 06013.

OVERPRINTED — 1981 Fox-Tango Club Newsletters. Sixty loose-leaf pages packed with modifications and information on Yaesu rigs. Only $6 while they last. Also a few 1980 sets at $5. (Overseas add $3 each, airmail.) N4ML, Box 15944, W. Palm Beach, FL 33406.

HAM RADIO OPERATORS who are owners of Atari Micro-Computer systems. Join the Atari Micro-computer net to exchange ideas on applications, programming, hardware and software development. Please contact Jack McKirgan II, WD8BNG, 4749 S.R. 207 N.E., Washington C.H., Ohio 43160. (614) 869-3597.

SALE — HW-16 $125 (w/crystals $150). 2 Johnson matchbox tuners, best $50, other (needs repair) $25. Heath 2 meter mobile amp $30. 10-40 vertical $25. You pay shipping. KA4EBW, Jim Howell, 18 Dan Street, Salisbury, NC 28144.

SATELLITE TELEVISION: Information on building or buying your earth station. Six pages of what's needed, where to get it, etc. $4.00 to Satellite Television, RD #3, Oxford, NY 13830. Parabolic antenna construction book also available. Send SASE for details.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Willams, PO #7057, Norfolk, VA 23509.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

CORDLESS TELEPHONES — Low prices, all major brands. Inquiries or Visa/MasterCard orders call (206) 743-3977 or Write Trinetics, Box 6005, Lynnwood, WA 98036.

VERY in-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

MICROWAVE CONVERTERS, decoders. Catalog 20¢. G.W. Electronics, P.O. Box 688, Greenwood, Indiana 46142.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

PURPLE HEART VETERANS: Organizing national Amateur Radio Chapter and Net to be affiliated with Military Order of the Purple Heart, Inc. For information and applications contact Clem Harris, KC5MM (ex WB5VDL), 6110 Pecan Trail Dr., San Antonio, TX 78249. (512) 699-1420.

Coming Events
ACTIVITIES
"Places to go..."

ALASKA: The Arctic Amateur Radio Club of Fairbanks will hold a Hamfest, June 5, Kiwanis AG Hall, Tanana Valley Fairgrounds. Doors open 8 AM. $5 sellers' fee. There will be a Left Footed Key for a code contest ending at 5 PM for a pot luck dinner. Also ARRL representatives and Alaska QSL Bureau will be there. For information: Herb Walls, KL7JLF, P.O. Box 1625, Fairbanks, AK 99707.

ARKANSAS: The Northwest Arkansas Amateur Radio Club's 2nd annual Hamfest/Swapmeet, Saturday, May 15, Community Building, Rogers on US Hwy. 71. 8 AM to 4 PM. Commercial exhibitors and flea market tables/space FREE. Doors open 8 AM. Main prizes include a complete Kenwood station, Icom IC2AT hand-held, Diawa Model 720 cross-needle SWR/power meter. Door prizes. Free parking. MARS, DX and Skywarn. Talk-in on 146.16/.76 or 146.52 simplex. Main prize tickets 3/$5.00 or $2.00 each. For information: Mary Webb, KA5HEV, P.O. Box 338, Prairie Grove, AR 72753. (501) 846-2847.

CALIFORNIA: The Fresno Amateur Radio Club's 40th annual Hamfest, May 21, 22 and 23, Hacienda Inn, Clinton and Highway 99, Fresno. Activites include a golf tournament, swap tables, CW contest, MARS meetings, transmitter hunt, cocktail hour, banquet. Talk-in on 146.34/93. Advance registration $20.00. For information/registration: Fresno Amateur Radio Club, Inc., P.O. Box 783, Fresno, CA 93712.

COLORADO: The Rocky Mountain VHF Society's annual spring Hamfest, Sunday, May 23, 9 AM to 3 PM, rain or shine, Boulder National Guard Armory, 4750 North Broadway. Donation $2 per family. Gates open for sellers 8 AM. Bring own tables. Door prizes include synthesized FM transceiver. Extra raffle tickets available. Refreshments available. Talk-in on 146.16/.76 and 146.52. For information: Richard Ferguson, KAØDXM, 1150 Albion Rd., Boulder, CO 80303. (303) 499-2871.

COLORADO: SUPERFEST 4 sponsored by the Northern Colorado Amateur Radio Club, June 5, 8 AM to 4:30 PM, McMillen Building, Larimer County Fairgrounds, Loveland. $3 admission includes swap table. Exhibits, tech talks, code contest with prizes, auction, swapfest, prize drawings including a synthesized 2-meter hand-held. Food service, free parking. Special activities for non-Hams and kids. For information: Gene Bellamy, WDØDRM, 3124 West 6th Street, Greeley, CO.

GEORGIA: The Anderson, Hartwell and Toccoa Amateur Radio Clubs' 4th annual Lake Hartwell Hamfest, May 22 and 23, Lake Hartwell Group Camp, Highway 29. Free admission, free camping (campground opens 6 PM Friday) free flea market space. Bingo, horsehoes, a left-footed CW contest and other activities for the whole family. Fishing, swimming on site. Main prize drawing 2 PM Sunday. Talk-in on 146.19/.79, 147.93/.33 and 146.895/.295. For information: Ray Pettit, WB4ZLG, Rt. #1 Dooley Drive, Toccoa, GA 30577.

IDAHO: The Kootenai Amateur Radio Society's Hamfest '82, Saturday, June 12, 8 AM to 4 PM, Kootenai County Fairgrounds, north of Coeur D'Alene on old Highway 95. Prizes, flea market, food available. No pre-registration, free tables available. Talk-in on .38/.98. For information: SASE to Avon Anderson, WB7WBZ, N. 1035 Highland Ct., Post Falls, ID 83854.

ILLINOIS: The Illiana Repeater System's 13th annual Danville Area Hamfest, May 23, Georgetown Fairgrounds. Flea market, forums, family entertainment, free parking. Many prizes. Gates open 6 AM. Tickets $2.50 advance, $3.00 gate. Talk-in on 22/82 and 146.52. For information, tickets, tables: Wendell Lyons, KA9AYS, Hamfest Chairman, 930 Polk St., Danville, IL 61832. (217) 431-2124.

INDIANA: The Tristate Amateur Radio Society's annual Hamfest, Sunday, May 16, Vanderburgh County 4H Center, Evansville. Grounds open 6 AM. Admission $2. Outdoor flea market. Indoor tables available. Talk-in on 147.75/.15 and 146.19/.79. For information/table reservations: Hal Wilson, WB9FNN, R.R. #8, Box 427B, Evansville, IN 47711.

INDIANA: The 3rd annual MAARC (Muncie Area Amateur Radio Club) Hamfest, May 23, 8 AM to 3 PM, Ball State University indoor track building, Muncie. Prizes, forums, refreshments, parking. Flea market tables $4.00. Talk-in on 146.13/73, 146.52, 223.10/224.70. Tickets $2.00 advance; $3.00 door. For information: Terry Evans, WD9HQH, 522 S. Brotherton, Muncie, IN 47302. (317) 282-0615.

INDIANA: The Wabash County ARC's 13th annual Hamfest, Sunday, May 16, 5 AM to 4 PM, Wabash County 4-H Fairgrounds, Wabash. Admission $2.50 advance; $3.00 gate. Plenty of food and parking available. Free overnight camping Saturday. Talk-in on 147.63/.03 or 146.52 simplex. For information/tickets SASE to Dave Spangler, N9ADO, 45 Grant St., Wabash, IN 46992.

KANSAS: The Chippewa Amateur Radio Club is having its 20th annual Hamfest, May 23, at Garnett North Lake, Garnett. For information: Reid Richardson, 518 West 7th, Garnett, KS 66032.

KENTUCKY: The N.K.A.R.C.'s annual HAM-A-RAMA, Sunday, May 23, Burlington Fairgrounds, Burlington, off 2-75 Florence exit. Tickets $4.00 each; family ticket $6.00. Each ticket entitles you to major prize drawing at 4 PM. First prize: Kenwood TS-130S or $500.00. Second prize: Kenwood HC-10 station clock. Special raffle for Icom 2AT. Door prizes every hour. Indoor vendors, flea market, refreshments. Talk-in on 146.19/79 and 147.86/26. For information — Jack R. Thompson, 637 Wolf Rd., Covington, KY 41015 or call (606) 291-2153.

MAINE: The Portland Amateur Wireless Association and the Southern Maine University Radio Club will hold their annual Flea Market, May 22, Gorham, Maine campus. 8 AM to 4 PM. Admission $1.00. Food available. If raining, will be held inside. Talk-in on 146.73R and 146.52S. For information: John Taylor, N1SD. (207) 773-2651.

MARYLAND: The eighth annual Easton Amateur Radio Society's Hamfest, May 16, rain or shine, 8 AM to 4 PM, Easton Senior High School. Donation $2.00 plus $2.00 for tables or tailgaters. Talk-in on 52 simplex and 146.445/147.045 repeater in Easton. Van Herridge, WB3HGQ, Box J, St. Michaels, MD 21663 or Easton ARS, Box 781, Easton, MD 21601.

MARYLAND: The Maryland FM Association's annual Hamfest, Sunday, May 30, Howard County Fairgrounds, West Friendship, 8 AM to 4 PM. Donation $3.00. Tail-

More Details? CHECK—OFF Page 100

gating $3.00. Advance tables $6.00 each. Limited quantity at door $10.00 each. Talk-in on 146.16/76 and .52. For information: MFMA Hamfest Committee, PO, Harmans, MD 21077. For Table info/reservations: John Elgin, WA3MNN, 5495 Apt. 2, Harpers Farm Road, Columbia, MD 21044. (301) 596-3741.

MASSACHUSETTS: *The South Shore Repeater Association's* annual Ham Radio/Electronic/Computer Flea market, Saturday, May 22, Weymouth South High School Cafeteria, 300 Pleasant Street, Weymouth. Doors open for sellers 9 AM; buyers 10 AM. Admission $1 each buyer. Tables $5 advance; $8 as available at door. Refreshments available. All proceeds support the 147.90/30 Weymouth Repeater. For information/advance tables: SSRA, David Newman, P.O. Box 447, Abington, MA 02351.

MASSACHUSETTS: The Hampden County Radio Association's annual Flea Market, Feeding Hills Congregational Church, Rts. 57 and 187, Feeding Hills, May 7, 8 PM. Talk-in on 146.34/94. For information: Larry Langevin, K1GXU. (413) 583-8236.

MASSACHUSETTS: The eighth annual Eastern VHF/UHF Conference, May 14-16, Sheraton Inn and Conference *Center, Boxboro. Activities of interest to the serious* VHFers. Friday night hospitality room. Saturday night banquet, featuring roast sirloin of beef, $14.00 before May 10. Registration $13.50 to K1LOG, Rick Commo, 3 Pryor Rd., Natick, MA 01760 before May 10. Door registration $20.00.

MICHIGAN: The Central Michigan Amateur Repeater Association's eighth annual Hamfest, June 12, Valley *Plaza Complex, off Rt. 10, Midland.* 8 AM to 4 PM. Donation $3.00. Children under 12 free. Tables $6.00; trunk sales $2.00. Free parking. Hourly prize drawings. Major prize drawing 2:30. Talk-in on 146.67/07 and 146.52 simplex. Motels, RV hookups, swimming, dining, bowling alley, theaters, picnic area at Hamfest location. For information: Carol Hall, WD8DQG, 4651 Cardinal Dr., Mt. Pleasant, MI 48858. (517) 772-0363.

MICHIGAN: The Chelsea Swap and Shop, Sunday, June 6, Chelsea Fairgrounds, Chelsea. Gates open for sellers 5 AM; public 8 AM to 2 PM. Advance donation $2.00; $2.50 gate. Children and non-ham spouses admitted free. Talk-in on 146.520 simplex and 147.855 Chelsea Repeater. For information: *William Altenberndt, 3132 Timberline,* Jackson, MI 49201.

MICHIGAN: The Independent Repeater Association's annual Grand Rapids Festival Swap & Shop, Saturday, June 5, 8 AM to 3 PM, Kentwood Field House, south of 60th Street on Kalamazoo Avenue. Admission $3.00. 8 ft. swap tables $7.00; $4.00 half size. Prizes and refreshments. For information or dealer reservations: I.R.A. SWAP, 562 - 92nd St. S.E., Byron Center, *MI 49315 or call* (616) 455-2926.

MINNESOTA: The North Area Repeater Association's Swapfest and Exposition for radio Amateurs and computer hobbyists, June 5, Minnesota State Fairgrounds, St. Paul. Admission $3. Exhibits, booths, prizes. Free overnight parking for self-contained campers, June 4. Call wide area repeaters 25/85 or 16/76 for directions. For information/reservations: *Amateur Fair, P.O. Box 30054,* St. Paul, MN 55175.

MISSISSIPPI: Old Natchez Amateur Radio Club's Hamfest, Sunday, May, Natchez Convention Center. Doors open 8 AM. Free admission and swap tables. Food available. Talk-in on 146.31/91. For information: S.W. Gates, N5AXV, P.O. Box 203, Natchez, MS 39120.

***MISSOURI* & KANSAS:** Pittsburg Repeater Organization's 8th annual Hamfest and Picnic, Sunday, May 23, Lincoln Center, Pittsburg, Kansas. Covered dish picnic, chicken and soft drinks supplied. Open 10 AM. Free parking; indoor flea market; door prizes. Grand prizes: FT-208R, Cushcraft Boomer, Ringo Ranger. Grand prize tickets (hams only) $2.00 each to KCØES, 505 Karen Drive, Carl Junction, MO 64834.

MISSOURI: The Indian Foothills Amateur Radio Club's 7th annual Hamfest, May 16, Saline County Fairgrounds Building, Marshall. Tickets $2.00 each; 3/$5.00 at door or 4/$5.00 advance. No charge for tables but reservations requested. Doors open 8 AM. Coffee and rolls available till 10 AM. An all-you-can-eat lunch at 11:30. First prize drawing 2:30 PM for a KDK 2025 Mark II. Talk-in on .52, .28/.88 and 147.84/.24. For information and tickets: Jim Little, KBØDA, 405 E. Rosehill, Marshall, MO 65340. (816) *886-8583 after 5 PM or* KØBVB (816) 886-2837.

NEW JERSEY: The Fort Monmouth ARC and Haverim are sponsoring the Jersey Shore Hamfest and electronic flea market, June 6, 9 AM to 4 PM, Jewish Community Center, 100 Grand Ave., Deal. Admission $3 per person (children under 12 and XYLs free). Refreshments available. Door prizes. Table ($5) and tailgating ($2) spaces may be reserved by SASE and advance payment to: *Jersey Shore Hamfest,* P.O. Box 2078, Ocean, NJ 07712 by May 25. Talk-in on 147.045 and .6; 146.775/.6; 146.52.

NEW YORK: The 30th annual ROME HAM FAMILY DAY sponsored by the Rome Radio Club, Sunday, June 6, Beck's Grove, Oswego Road, Rome. Activities for Hams and non-Hams; door prizes, presentations of an educational and scientific nature, the area's largest Flea Market. An early brunch will be available as well as a fine buffet dinner. Talk-in on 28/88 and 146.55 simplex. Beck's Grove has overnight parking for campers as well as fly-in capabilities. For information: Rome Radio Club, P.O. Box 721, Rome, NY 13440.

NEW YORK: The Putnam Emergency Amateur Repeater League's first annual indoor Hamfest, Saturday, May 8, 9 AM to 4 PM, JFK Elementary School, Foggintown Road, off Route 312, Brewster. General admission 50¢. Exhibitors $2.00. Talk-in on 52 and 146.135/144.535. For information/advance table registration: Frank Konecnik, WB2PTP, RD1-224C, Carmel, NY 10512.

NEW YORK: The Long Island Mobile Amateur Radio Club's Hamfair '82, May 23, Islip Speedway, Long Island. General admission $2.00, exhibitors $5.00 per car space. Refreshments available. Door prizes and special prizes drawn all day from 9 AM to 4 PM. Talk-in on 146.85. For information call Sid Wolin, K2LJH (516) 379-2861 or Hank Wener, WB2ALW (516) 484-4322 (evenings).

NORTH CAROLINA: The Durham FM Association's annual Durhamfest, May 15, South Square Mall, U.S. 15-501 south. Admission $3.50 including dealers. Prizes, flea market, free tailgating spaces, overnight parking. Talk-in on 147.825/225. For information: Durhamfest, Box 777, Hillsborough, NC 27278.

OHIO: The Champaign Logan Amateur Radio Club's annual Hamfest and Flea Market, Sunday, June 13, Logan County Fairgrounds, Bellefontaine. Gates open 7 AM EDST. Hourly prize drawings 9 AM to 3 PM. Major prizes of $200, $100 and $50 drawn at 3 PM. Tickets $1.50 advance, $2.00 door. Tables $3.00 advance. Contact M.A. Griswold, W8JXM, P.O. Box 301, Urbana, OH 43078 for information, tickets or tables.

OHIO: The 15th annual Goodyear ARC Hamfest, Sunday, June 13, 10 AM to 5 PM, Goodyear Wingfoot Lake Park, near SR224 and 43 east of Akron. Family admission $2.50 advance, $3.00 gate. Outside flea market $1.00 per space. Inside dealers $5.00 per table. Suggest reservations. Prize drawings throughout day. Grand prizes: First — Kenwood TS-830S; second — Yaesu FT-290R; third — Kenwood TR-2500 and more. Ladies' prizes too. For tickets and information SASE to Don W. Rogers, WA8SXJ, 161 S. Hawkins Avenue, Akron, Ohio 44313. (216) 864-3665.

OHIO: The Athens County ARA annual Hamfest, Sunday, May 16, Athens City Recreation Center, East State St., 8 AM to 4 PM. Free flea market for electronics-related items. Setup 7 AM. Tickets $1 advance; $2 gate. Nearby restaurants and recreation area. Talk-in on 34/94. For information SASE to: ACARA, P.O. Box 72, Athens, Ohio 45701 or telephone Joe Follrod, WB8DOD, (614) 797-4874.

OHIO: The Ohio Radio Club and the Ottawa County Amateur Radio Club and area dealers are sponsoring a Hamfest, May 23, Fremont, Ohio, Fairgrounds. Gates open 8 AM. Dealer setup 7 AM. Advance tickets $2.50, $3.00 door. Talk-in on 31/91 and 52. For table reservations/tickets SASE to: John Dickey, W8CDR, 545 N. Jackson St., Fremont, OH 43420.

OREGON: The Oregon State Ham Convention co-sponsored by the North Coast Repeater Association and the Oregon Tualatin Valley Amateur Radio Club, June 4 - June 6, Seaside Convention Center, Seaside. Friday 12 Noon to 5 PM; Saturday 8 AM to 9:30 PM; Sunday 8 AM to 2 PM. Registration $5.00/single; $7.00/couple; $1.00 children. A special ticket for a drawing of either an Icom 2AT, 3AT, or 4AT plus extra tickets for main prize drawing will be given to those who preregister before March 31. Registrations between April 1 and 30 will receive one extra ticket for main prize drawing. Seminars on receiver design,. construction, contests and more. Talk-in on 146.52 and local repeater 145.45. For information/reservations: Doc McLendon, W7GWC, P.O. Box 920, Seaside, OR 97132.

PENNSYLVANIA: The 11th annual MARC (Milton Amateur Radio Club) Hamfest, June 6, rain or shine, Allenwood Firemen's Fairgrounds, U.S. Rt. 15, 8 AM to 5 PM. Advance registration $2.50; $3.00 gate. XYLs and children free. Flea market, auction, contests. Cash door prizes. Camping and motels nearby. Talk-in on 37/97, 025/625 and 52 simplex. For details: Jerry Williamson, WA3SXQ, 10 Old Farm Lane, Milton, PA 17847. (717) 742-3027.

PENNSYLVANIA: The 28th annual Breeze Shooters Hamfest, May 23, Noon to 5 PM, White Swan Amusement Park, PA, Rt. 60 near Greater Pittsburgh International Airport. Registration $2.00 each; 3/$5.00. Free flea market, prizes, family amusement park. Talk-in on 146.28/.88 or 29.0 MHz. Contact Joe Kyler, K3SJD, 4430 Evergreen Road, Pittsburgh, PA 15214. (412) 931-2756.

PENNSYLVANIA: The Warminster Amateur Radio Club's annual Hamfest, Sunday, May 16, Middletown Grange Fairgrounds, Wrightstown (near Philadelphia), 7 AM to 3

PM. Admission $3.00 gate; $2.00 additional for each seller space. Children and spouse free. Pre-registration by May 1, $1.00 off admission. Door prizes every half hour starting 9 AM. Talk-in on 147.690/090 and 146.52 simplex. For information: P.O. Box 113, Warminster, PA 18974 or call Bill Scott, KA3CHB after 6 PM (215) 249-0568.

PLAYBOY RESORT at Great Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07631.

TENNESSEE: The ARRL Delta Division Convention and 16th annual Knoxville Hamfest, May 22 and 23, Bearden High School, 8352 Kingston Pike, Knoxville, Saturday 9 AM to 5 PM; Sunday 10 AM to 4 PM. General Admission: $2 advance; $3 door. All tickets good for grand prizes and door prizes. Exhibitors $8/table both days; $5/table one day. Grand prizes: cash plus many door prizes. Bonus prize Saturday morning drawn on advance tickets. Forums: DX, ARRL, fast scan TV. Women's programs, outdoor flea market, own tables. Saturday banquet, 7:30 PM, Sheraton Executive Park, Knoxville, tickets $15.00. For information, tickets, reservations: Raymond Adams, N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, TN 37921. (615) 688-7771 Days. (615) 687-5410 Nights.

TENNESSEE: The Humboldt ARC's annual Hamfest, Sunday, June 6 at New Location — Bailey Park, N. 22nd Avenue, Humboldt. Tickets $2.00. Prizes, flea market, ladies' and children's activities. For information: Ed Holmes, W4IGW, 501 N. 18th Avenue, Humboldt, TN 38343.

KNOXVILLE TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

VIRGINIA: The Ole Virginia Hams ARC of Manassas announces its eighth annual Mid-Atlantic are Quality Hamfest, June 6, Prince William County Fairgrounds. Gates open 8 AM. Tailgating setup 7 AM. Admission $4.00, children under 12 free, tailgaters $3.00 additional per vehicle. Indoor/outdoor exhibits, YL program, refreshments available. Fantastic prizes. Bring your family. Talk-in on 37/97 and 52 simplex. For information: Jim Lascaris, WA2QEJ, 11053 Camfield Ct., Manassas, VA 22110.

WEST VIRGINIA: The Tri-State Amateur Radio Association's 20th annual Huntington Hamfest, Sunday, June 13, Camden Park off route 60 west. 9 AM to 3 PM. Registration $3 per person. Children under 12 free. Flea market $3 per space. Overnight parking for self-contained RVs. Talk-in on 146.04/64 and 146.52/52 W8VA. For information SASE to T.A.R.A., Inc., P.O. Box 4100, Huntington, WV 25729.

WISCONSIN: The 7th annual Swapfest of the Green Bay Mike and Key, Saturday, May 22, Norwood School, corner of 9th and Norwood, Green Bay. 8 AM to 3 PM. Advance tickets $1.50 (by May 1), $2.00 door. Tables $2.00/4 ft. space. Free admission for one for every 2 tables bought. Door prizes. Refreshments available. Talk-in on 146.52 and 147.72-.12. For information: Robert Duescher, 1011 - 13th Avenue, Green Bay, WI 54304.

ONTARIO: The Guelph Amateur Radio Club's 7th annual Central Ontario Flea Market, Saturday, June 5, 8 AM to 4 PM, Regal Hall, 340 Woodlawn Road West, Guelph. Admission $2.00; under 12 free. Vendors $3 additional. Tables available at $5 each. Commercial displays, surplus dealers, computer software/hardware. Refreshment concession. For information: Bob Lacombe, VE3IYE, (519) 843-4618 or Rocco Furfaro, VE3HGZ, (519) 824-1157.

OPERATING EVENTS

"Things to do..."

MAY 12-16: The Holland Amateur Radio Club will operate K8DAA with other participating stations for the Netherlands-American Bicentennial during Tulip Time. Operations on all phone bands and possibly some CW. One contact with K8DAA or two participating stations qualifies for certificate. QSL to HARC, P.O. Box 92, Zeeland, MI 49464.

MAY 15 & 16: The Rockingham County ARC will be operating from the Cape Hatteras Lighthouse on the Outer Banks of North Carolina. This is the tallest brick lighthouse in the country and is designated as a National Historic Landmark. Operating frequencies: 30 Kc up from bottom of general portion of each band, phone and CW.

MAY 16 & 17: W7AQ, the Yakima Amateur Radio Club, will operate a special event station in commemoration of the second anniversary of the eruption of Mt. Saint Helens in Washington State. Join us at 1800 May 16 to 0200 May 17 UTC. Frequencies will be 25 kHz up from bottom of General phone edge; CW up 25 kHz from Novice band edge and at 14.050, all ± QRM and band conditions. A QSL will be available for a SASE to W7AQ, Yakima ARC, P.O. Box 9211, Yakima, WA 98909.

MAY 21-30: The Wiesbaden Amateur Radio Club announces its seventh annual DXpedition to Liechtenstein, callsign DA1WA/HB0. CW, phone and RTTY, all frequencies, 10 to 160 meters including three new WARC bands. CW operations for American stations will be attempted at 3.725 and 21.120 MHz between 1900 and 2100 EST. Stateside QSLs SASE to Stephen Hutchins, Box 4573, APO New York 09109.

MAY 22 & 23: The Clark County Amateur Radio Club, W7AIA, announces the 2nd annual Mount Saint Helens QSO Party. May 22 0001 UTC through 2359 UTC May 23. Frequencies: SSB — 3.805, 7.230, 14.280, 21.360, 28.505. CW — 3.705, 7.105, 21.105, 28.105. VHF — Various Vancouver and Portland area repeaters. To apply for a Mt. Saint Helens Award, send log information or QSL card and $2.00 (or 8 IRCs) to: Award Manager, W7AIA, P.O. Box 1424, Vancouver, WA 98668. All proceeds from the award will go to the Reid Blackburn Scholarship Fund which has been established by the Vancouver newspaper "The Columbian". Reid, KA7AMF, an active member of the club, lost his life during the disastrous eruption of May 1980 while monitoring a U.S.G.S. observation station near the base of Mt. Saint Helens.

MAY 22 TO JUNE 7: The Smiths Falls Amateur Radio Club will be operating a special events station, CZ3SFR, on all HF bands and 2 meters VHF, commemorating the 150th anniversary of the Rideau Canal System linking Ottawa and Kingston. For a special QSL send business SASE to: P.O. Box 215, Smiths Falls, Ontario, Canada K7A 4T1.

MAY 29 & 30: The Neffs Area Amateurs (Belmont County) will operate WB8TQG, the smallest Ham Radio shack in Neffs, Ohio. Work us and let us know if you have a smaller one. May 29 1600Z to May 30 2200Z. Frequencies: Phone 146.46, 28.610, 21.410, 14.340, 7.265, 3.965. CW 28.120, 21.120, 7.120, 3.720. Certificate for QSL card and business SASE to WB8TQG, Floyd, P.O. Box E, Neffs, OH 43940.

MAY 29 & 30: The Orange County ARC will operate WB2TSA to celebrate the Club's tenth anniversary and the Diamond Jubilee of the city of Port Jervis, New York. May 29 1400-2200 UTC and May 30 1400-2000 UTC. Frequencies: 10 kHz up from lower General phone bands. SASE for QSL to OCARC, P.O. Box 434, Cornwall-On-Hudson, New York 12520.

MAY 31: The Bishop Amateur Radio Club will operate KA6AMT from the Mule Capitol of the World, Bishop, California, in recognition of the annual Mule Days celebration. Frequencies: Phone — 3.905, 7.240, 14.295, 146.34/94. For certificate SASE to: Bishop Amateur Radio Club, P.O. Box 1024, Bishop, CA 93514.

JUNE 5: The Pennyroyal Amateur Radio Society's annual Jefferson Davis QSO party, on Saturday, 1500 to 2400 UTC. Suggested frequencies: 3.940, 7.260, 14.310, 21.410 and 28.610 MHz phone and 3.730 MHz CW. An attractive certificate for contacts made that day will be available.

JUNE 5 & 6: Fort Delaware, on Pea Patch Island, Delaware, will be the site of a mini-expedition by Wilmington area hams operating in the General portion of the HF bands during daylight hours only, each operator using his own call and the Fort Delaware identifier. Operators include N3ACU, Doug; N3ARU, Dwight; N3ARV, Ned; KB3HZ, Allen; KB3PD, Rick. This will be the first HF Amateur communications from the fort in the middle of the Delaware River where many Confederate prisoners of war were held during the Civil War. Commemorative QSL cards will be issued for contacts supplying SASEs.

JUNE 12: The Tri-City Amateur Radio Club will operate a special event station from the replica of Stonehenge, near Maryhill, Washington. W7VPA will operate from 1600 to 0100 UTC on or near 3.900, 14.290, 28.690 and 146.52. An attractive certificate will be awarded. Send QSL info and $1.00 to W7VPA, Special Event, P.O. Box 73, Richland, WA 99352.

TO MILITARY COMMUNICATORS: If you have ever served, or are currently serving, with the U.S. Army Signal Corps, either in the military or as a civilian employee, you are invited to join the U.S. Army Signal Corps Association. Communicators from sister services and allies are also welcome to join. Members of the Association receive copies of the *Army Communicator*, the voice of the Signal Corps, as a benefit of membership. Additional information and applications for membership are available by contacting: Signal Corps Association, P.O. Box 7740, Fort Gordon, Georgia 30905.

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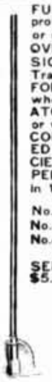

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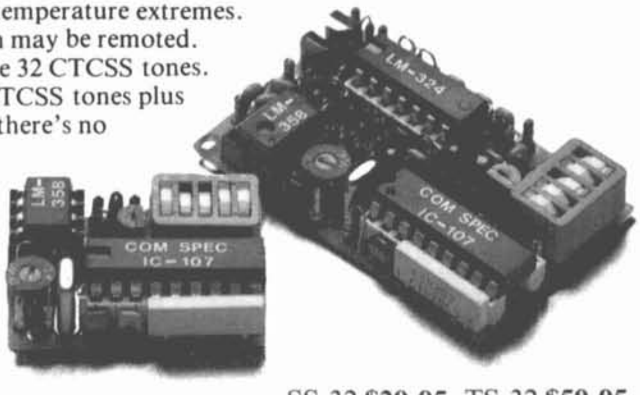
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Using two 8-pole filters in the IF, Yaesu's pioneering variable bandwidth system provides continuous control over the width of the IF passband — from 2.4 kHz down to 300 Hz — without the shortcomings of single-filter IF shift schemes. No need to buy separate filters for 1.8 kHz, 1.5 kHz, etc.

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- **AC power supply built-in.** 120, 220, or 240 VAC, switch selected (operates on AC only).
- **Fluorescent tube digital display.** Fluorescent tube digital display has analog type sub-scale with 20-kHz steps. Separate 2 digit display indicates RIT frequency shift.
- **RF speech processor.** RF clipper type processor provides higher average "talk-power," plus improved intelligibility. Separate "IN" and "OUT" front panel level controls.
- **One year warranty.** The TS-930S carries a one year limited warranty on parts and labor.

Other features:

- SSB monitor circuit, 3 step RF attenuator, VOX, and 100-kHz marker.

Optional accessories:

- AT-930 automatic antenna tuner.
- SP-930 external speaker with selectable audio filters.
- YG-455C-1 (500 Hz) or YG-455CN-1 (250 Hz) plug-in CW filters for 455-kHz IF.
- YK-88C-1 (500 Hz) CW plug-in filter for 8.83-MHz IF.
- YK-88A-1 (6 kHz) AM plug-in filter for 8.83-MHz IF.
- MC-60 (S-8) deluxe desk microphone with UP/DOWN switch.
- TL-922A linear amplifier.
- SM-220 station monitor.
- HC-10 digital world clock.
- HS-6, HS-5, HS-4 headphones.

More information on the TS-930S is available from all authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street, Compton, California 90220

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Specifications and prices are subject to change without notice or obligation.